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# SELECTED URBAN STORM WATER RUNOFF ABSTRACTS. A COMPILATION OF SELECTED ABSTRACTS ON STORM WATER DISCHARGES AND COMBINED SEWER OVERFLOWS

Franklin Institute Research Laboratories
Philadelphia, Pennsylvania

January 1969

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# Selected Urban Storm Water Runoff Abstracts

A Compilation of Selected Abstracts on Storm Water Discharges and Combined Sewer Overflows

FEDERAL WATER POLLUTION CONTROL
ADMINISTRATION
U. S. DEPARTMENT OF THE INTERIOR

by

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# F O R E W O R D

SELECTED URBAN STORMWATER RUNOFF ABSTRACTS is a compilation of abstracts summarizing articles from a variety of technical publications, covering the subjects of urban runoff, stormwater discharge, storm sewers, and combined sewers - together constituting "the problem of urban drainage". Articles on more general subjects, such as "sewerage" or "sanitary engineering", and topics not closely related to stormwater, such as "agricultural runoff", have been excluded.

The present work represents an effort to index, expand and update the annotated bibliograph, STORM WATER RUNOFF FROM URBAN AREAS, issued in April 1966 by the Cincinnati Water Research Laboratory of the Federal Water Pollution Control Administration. Among the 573 abstracts presented are 386 not previously included, which summarize articles dated both earlier and later than 1966, so that the present compilation represents as complete as possible a bibliographic record of stormwater articles, up to - and to some extent including - 1968. The 187 abstracts from the 1966 edition were indexed, but not otherwise edited or re-evaluated. For convenience, the abstracts are classed in eleven sub-topic categories, and arranged alphabetically by author within each category. Since most of the papers fit into more than one category, the cumulative subject index at the end of the volume provides the necessary access to individual concepts by referring to each pertinent abstract number. Each item includes a bibliographic citation, an abstract, and a set of indexing descriptors (subject terms listed in the Water Resources Thesaurus, November 1966 edition) and identifiers (newly suggested subject terms). The most important index terms are marked by an asterisk. The format of abstract presentation follows the one used by the Department of Interior's Water Resources Scientific Information Center for its periodical, Selected Water Resources Abstracts.

Copies of the articles abstracted in most cases can be obtained from research libraries covering water pollution or public health engineering literature. Some are not generally available and may be inspected at the offices of the Storm and Combined Sewer Pollution Control Branch, Division of Applied Science and Technology, Federal Water Pollution Control Administration, Department of the Interior, Washington, D. C., 20242. None of the articles are available for distribution by FWPCA.

Suggestions concerning the improvement of content and format, or expansion of subject coverage in future supplements to this compilation, will be gratefully received.

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# Section I

# INSTRUMENTATION AND CONSTRUCTION EQUIPMENT

001
A HORN FORETELLS SEWER OVERFLOWS.

Amer City, p 58, May 1967.

Descriptors: *Instrumentation, *Overflow, *Sewers.

An electronic device in use at five lift stations in Mc Pherson, Kan. which warns if sewage levels rise too high is described. When sewage rises too high it contacts an electrode, a light flashes and a horn blows in police headquarters. Device saves about 100 man-hours of work/month. A sketch and wiring diagram are given.

002
FLUID FLOW MEASUREMENT.
Calif Res Corp.

Brit Patent 862,891.

Descriptors: *Flow measurement, *Pipes, *Tracers, Velocity.

A method is claimed for determining rates of fluid flow and comparing relative rates of flow under different conditions in pipes, canals, or rivers, by introducing a known quantity of radioactive material and monitoring the stream to obtain a time-integral value of the effect of the radioactivity during its passage or transit past a given point (by integrating the response of a radioactivity detector such as a Geiger counter). The method is based on the discovery that the integral or total number of gamma or other suitable radioactive rays detected is inversely proportional to the velocity of flow, but is independent of the way in which the radioactivity is spread out along a segment of the fluid stream as the result of flow conditions.

003
PROGRESS REPORT OF THE STORM DRAINAGE RESEARCH PROJECT.
Johns Hopkins U, Dep Sanit Eng and Water Resources, Baltimore, Md.

Report No. 10: July 1, 1961 to June 30, 1962, Baltimore, June 1962.
187 pp, graphs, figures.

Descriptors: *Instrumentation, *Storm runoff, Rain gages, *Flow measurement, *Weirs.
Identifiers: *Storm sewers, Surface permeability.

The results of the project's effort to develop reliable rainfall and stormwater runoff measuring instruments are presented. A depth type pressure sensing device for measuring the flow at a single point in a storm sewer, and a sharp-crested sensing weir for measuring the runoff entering a stormwater inlet, have been developed. It is felt that these instruments can be employed by other agencies with very few changes. The observation of widely differing amounts of runoff from storms of the same frequency, with changes in soil permeability as a factor, is one of the other problem areas mentioned.

004
AUTOMATIC CONTROL VALVES.
Foxboro Co., Foxboro, Mass.
R. H. Babcock.
Water Wastes Eng, Vol 5, No 1, pp 43-5, Jan 1968.

Descriptors: *Automatic control, *Flow control, *Instrumentation, Sewage treatment, Hydraulics.
Identifiers: *Calculations.

Many specialized valves are now incorporated in the automatic control of sanitary systems and successful application of a control valve to a process requires complete understanding of the hydraulics of the system under design. Design techniques for control problems involve flow of reagents (pH control) pipline losses, inlet losses, outlet losses, and fitting losses. In every case a valve can be considered a control of simple flow between two reservoirs. A valve may also be considered a variable orifice. Derivations of sizing equations for (1) liquids, (3) gases and (3) steam and other vapors are given. A table presents typical valve coefficients for valve types such as butterfly, needle, and wide range V port. Some typical valve sizing problems are presented and solved by application of the equations derived.

005
TV SEWER INSPECTION.

Robert H. Brindley.
Amer City, Vol 79, pp 87-89, Jan 1964.
(through Public Health Eng Abstr, Vol 43, p 310, 1963).

Descriptors: *Equipment, Sewers.
Identifiers: *Sewer inspection.

The television sewer inspection equipment of the Hartford, Conn., Metropolitan District is described in the article. Inspections have proven effective in locating house laterals, finding sewer obstructions, and determining condition of sewers. A crew consists of television operator, forward winch man, and cable guide man. The camera can best be pulled through the sewer by a hand winch that has reduction gears with a pulley and brace mounted in the manhole. A direct-wire intercom with a talk-back speaker provides communication and permits the winch man to keep both hands free. Sewers needing cleaning or flowing over one-third full are not conducive to TV inspection. Difficulties in the use of the equipment have been resolved: camera skids have been modified to prevent fouling of lines; a more powerful camera light has been installed for use in small sewers; work has been rescheduled when radio frequency interference occurred; and fog has been moved through the sewers by a portable blower forcing air into the manhole.

006
LARGEST SEWER PHOTO INSPECTION.

C. E. Cannon.
Amer City, Vol 80, No 1, pp 98-9, Jan 1965.
(through Eng Index, p 2238, 1965).

Descriptors: *Sewers, *Equipment.
Identifiers: *Sewer inspection, *Storm sewers.

Extensive underground photographic survey, carried out at Anchorage, Alaska, to assess damages, caused by earthquake, covered 600,000 ft of 8- to 21-in. sanitary and storm sewers. Inspectoline camera equipment and Wayne 3-D Pipeline Survey cameras were employed by two inspection groups. Methods followed to determine condition of pipe lines are described.

007
MAGNITUDE AND FREQUENCY OF FLOODS IN SUBURBAN AREAS.

R. W. Carter.
U S Geol Surv Prof Pap 424-B, B.9-B.11, 1961.

Descriptors: *Drainage systems, *Hydrographs, Land use, *Infiltration, Peak discharge, *Floods.
Identifiers: *Suburban drainage, Washington, D.C., *Surface permeability.

Suburban development changes two of the basic elements that determine the magnitude and timing of the volume and peak of the flood hydrograph, namely the average infiltration rate (which is decreased because roofs and streets are impervious), and the lag time between rainfall excess and the floor hydrograph (which is decreased because of storm sewers and improvements to the principal stream channels). The net effect of these changes has been evaluated in the vicinity of Washington, D.C. After analyzing the data statistically, it is concluded that for drainage basins larger than 4 square miles in the Washington area the maximum effect of complete suburban development on flood peaks of any recurrent interval is expressed by the ratio flood discharge (suburban): flood discharge (undeveloped)=1.8.

008
MONITORING STORM-WATER OVERFLOWS.

A. D. Caster.
Water Pollut Contr Fed J, Vol 37, pp 1275-1280, 1965.
(through Water Pollut Abstr, Vol 39, No 3, p 94, March 1966).

Descriptors: *Overflow, *Water pollution control, Instrumentation.
Identifiers: *Interceptor sewers, Cincinnati, Ohio.

A description is given of the system installed at Cincinnati, Ohio, to detect when overflows occur from the sewers as a result of clogging of the interceptors with solid materials during normal dry-weather flow. A signalling device is fitted at each interceptor and the signal is transmitted to the telephone exchange. It is hoped by this means to reduce pollution of the various creeks within the metropolitan area.

009
NEW INSTRUMENT CAN MEASURE SEWAGE FLOW.

A. E. Cruchley.
Munic Eng, Vol 136, pp 814-815, 1959.

Descriptors: *Flow measurement, Surface drainage, *Sewers, *Flowmeters.

An illustrated description is given of a new instrument, developed by the Road Research Laboratory during investigations on surface water drainage, for recording flow in sewers. The device records variations with time in the rate of sewage flow and the periods of time during which the flow is in excess of certain values selected for particular study. The instrument is composed of a movement recorder and a time totalizer, the latter consisting of a time base and multiple-contact switch-unit within the movement-recorder and a separate box containing a rectifier and a battery of counters.

010
RESULTS OF RADAR MEASUREMENTS OF LIQUID PRECIPITATION.

A. M. Dimaksyan, and N. V. Zotimov.
Amer Geophys Union, Soviet Hydrol - Selec Pap, No 6, pp 530-7, 1965.
(through Eng Index, p 2279, 1967).

Descriptors: *Rainfall intensity.
Identifiers: *Radar measurement.

Correlations exist between strength of radio echo signals and rate of precipitation. Confirmation is given that differential calibration of radar installation makes it possible to measure intensity of rainfall irrespective of its nature during season or in different years, and that method may be applied to any type of radar station. Curve of sensitivity of radar installation in relation to characteristics of rainfall is given.

011
TEMPORARY FLOW MEASUREMENT IN SEWERS AND DRAINS.

M. H. Diskin.
ASCE Proc, J Hydraul Div, Vol 89, No HY4, Part 1, July 1963.

Descriptors: *Flow measurement, *Sewers, *Discharge measurement, Instrumentation.

Temporary flow measurement in circular channels, such as sewers and drains, as well as in sewers of other cross sections, can be carried out by introducing into the flow a pier-shaped element with a bottom rounded to fit the circular invert of the channel. The reduction in the area of flow causes a critical section to develop in the throat so formed, which gives a functional relationship between the discharge and the critical depth at the throat and also between the discharge and the depth at an upstream section adopted as a measuring section. The device is, in effect, a critical depth flume, or a Venturi flume, with an irregularly shaped throat composed of 2 openings on either side of the element introduced. Applying the theory of critical depth flumes, equations are derived relating the discharge to depth at the measuring section; the equations are solved numerically, making use of standard tables of properties of parts of a circle. The results of experiments performed on the proposed measuring device indicate fairly close agreement between the measured and the calculated rates of flow, most values of the coefficient of discharge falling in the range of 0.90 to 1.00. The experiments included tests on 4 measuring devices, 2 in each of 2 circular channels 10 in. and 16 in. diameter.

012

## A FIELD METHOD OF MEASURING AND RECORDING FLOW IN SEWERS.

Warren Ellis, and C. Thorne Johnston.
Public Works, Vol 94, June 1963.

Descriptors: *Sewers, *Flow measurement, Manholes, *Velocity, Roughness (hydraulic), *Instrumentation.

A method of measuring and recording flow in sewers is given as follows. Determine the size, length, and slope of a sewer between 2 manholes. For known depths of flow in this sewer determine velocities between the upper and lower manholes by using dye test and stop watch. From the velocity data determine roughness coefficient "n" through the Manning formula. Prepare a depth-discharge curve for the particular stretch of sewer. Using a stage recorder, continuously record the depth of flow in the sewer for desired period, and convert the depth data to flow rate. A portable, spring-wound stage recorder is used. A special ring to hold a bubbler tube with the tube opening at the sewer invert is mounted inside the sewer. Nitrogen gas from a bottle is bubbled through the tube, and the gas pressure required to discharge the gas beneath the liquid is recorded as depth of flow on the recorder chart. The special equipment used is described and illustrated. Costs of equipment are listed.

013

## SEWAGE SAMPLING.

L. B. Escritt.
Water Wastes Treat J, Vol 8, No 10, Nov-Dec 1961.

Descriptors: *Sampling, Instrumentation, *Sewage treatment.

Discussion on the value of sewage sampling points out the care that should be taken whether samples are collected by hand or machine and describes methods used in hand sampling, automatic sampling, and importance of weighted samples. A simple weighted automatic sampler of the type used by the London County Council at outfall works is described in detail. This sampler has no moving parts except a pump and collects 43 samples per day totaling 4 gallons at high flows and 12 samples per day, about 1 gallon of sample, during low flows in proportion to the flow.

014
METHODS AND EQUIPMENT FOR THE MEASUREMENT OF SEWAGE FLOW.

H. Fathmann.
Wasser Luft Betrieb, Vol 10, pp 668-673, 1966.
(through Water Pollut Abstr, Vol 40, No 7, p 314, July 1967).

Descriptors: *Flow measurement, *Weirs, Instrumentation, *Sewers.
Identifiers: *Calculations.

Quantitative measurements within a definite given time are often required for experimental purposes and operational research. For this purpose tank measurements are employed, using floats and measuring weirs. Stationary calculations on volume of sewage are carried out by measurements in pressure pipe lines according to the Venturi principle or as inductive measurements for the rate of flow.

015
REPORT OF U S WEATHER BUREAU STUDIES IN RADAR HYDROLOGY.

A. F. Flanders.
Int Geod Geophys Union - Sect Sci Hydrol Publ No 65, pp 360-71, 1964.
(through Eng Index, p 2044, 1965).

Descriptors: *Rain gages, Instrumentation.
Identifiers: *Radar measurement.

Progress made by U S Weather Bureau on measurement of precipitation by WSR-57 radar is presented. Various operational attempts, techniques and applications made in field of radar-hydrology show successes and limitations encountered as well as progress made with Radar Precipitation Integrator. Plans for utilization of radar as continuous recording rain gage as step toward automation in radar-hydrology-computer area are discussed.

016
FLOW MEASUREMENT TECHNIQUES.

G. D. Healy, Jr.
Instrum Contr Syst, Vol 38, No. 3, pp 111-15, March 1965.
(through Eng Index, p 800, 1965).

Descriptors: *Flow measurement, *Flowmeters, Instrumentation, *Sewers.

Review of flow measurement techniques commonly used for water and sewage, volumetric meters, timed volume flow, variable headmeters, pilot tube, orifices, venturi, nozzles and open channel techniques is presented.

017
ADJUSTMENT OF RADAR ESTIMATES OF STORM MEAN RAINFALL WITH RAIN GAGE DATA.

F. A. Huff.
J Appl Meteorol, Vol 6, No 1, pp 52-6, 1967.
(through Eng Index, p 2276, 1967).

Descriptors: *Rain gages, *Rainfall intensity, Storms.
Identifiers: *Radar measurement.

An evaluation of feasibility of using surface rain gage data to modify radar-rainfall equation for specific storm conditions is presented. Data used were for 19 storms. Study was restricted to warm-season, unstable precipitation and to use of 10-cm radar. Normal climatic network was found inadequate for modification, for area and conditions studied, if relatively accurate estimate is needed. However, correspondence of radar and rain gage patterns was much better with 10-cm radar than it had been with 3-cm radar.

018
A FIELD METHOD OF MEASURING AND RECORDING FLOW IN SEWERS.

C. Thorne Johnston, and Warren Ellis.
Public Works, Vol 94, No 6, p 124, 1963.

Descriptors: *Flow measurement, *Sewers, Instrumentation, *Flowmeters.

Article describes the use of a snap-ring tube jacked into a sewer pipe in which a bubbler-tube using nitrogen gas transfers flow depth to a recorder. This method requires that a depth-discharge curve be computed for a reach of sewer. Advantage is in cost and elimination of problems of location and operation of devices such as flumes.

019
BUILT TO BE SEEN.
Wilsey & Ham, Architectural, Engng, and Planning Consultants,
San Mateo, Calif.
Daniel W. Klar.
Amer City, pp 96-97, May 1967.

Descriptors: *Pumping, *Storm runoff.

A pump station in Foster City, Calif. is described. The station serves a community with an expected population of 35,000 in 1977, and with an average elevation of 4.5 ft. above sea level. The station has a system of levees, collecting lagoons and waterways for storm drainage. The pumps circulate 400,000,000 gals. of water each week to keep lagoons and waterways clean and clear. Pumping equipment and station layout are described.

020
FLUSHING OF SEWER NETWORKS: AUTOMATIC DISCHARGE DEVICE.

A. Lencastre.
Mem Minist Obr Publ, Lisbon, No 109, 1957.

Descriptors: *Automatic control, Instrumentation.
Identifiers: *Sewer flushing.

Investigations were carried out on 3 automatic discharge systems for use in flushing sewers, to determine the effectiveness of automatic operation even at very small rates of flow.

021
TV GOES UNDERGROUND AT FORT LAUDERDALE.

C. S. McKinney, R. W. Campbell, F. C. Funnell, et al.
Water Pollut Contr Fed J, Vol 38, No 2, pp 179-85, Feb 1966.
(through Eng Index, p 2739, 1966).

Descriptors: *Equipment, Sewers.
Identifiers: *Leak detection.

Small TV camera was used for viewing inside of pipe lines and locating failures of PVC jointed terra-cotta pipe to obtain data necessary to repair constantly developing leaks. Equipment included aluminum paneled van-type truck outfitted with portable generator for power, intercom system and radio for communications, cupboards and cabinets for storage, and air conditioning unit to keep truck and equipment cool for efficient operation. Camera, 6 3/4 in. in diam. had as its light source six miniature floodlights mounted around lens.

022
SOUTH SASKATCHEWAN RIVER PROJECT.

I. B. Mackintosh.
Water Power, Vol 15, No 9, pp 361-8, Sept 1963, pp 403-8, Oct 1963.
(through Eng Index, p 1733, 1964).

Descriptors: *Tunnel construction.
Identifiers: *"Mole" tunneling, Canada.

Project between Government of Canada and Province of Saskatchewan is featured that is aimed to irrigate 500,000 acres in area affected by droughts, develop hydroelectric power, provide urban water supply, give flood control and provide recreational facilities. Earthmoving operations on 8000 ft long 64 million cu yd dam are described in conjunction with embankment construction and construction of power intake shafts. Use of "Mole" tunnel boring machine for tunneling through shale.

023
STORM SEWER TUNNEL "THREADS NEEDLE" BETWEEN HIGHWAY BENTS.

W. D. Murphy.
Public Works, Vol 95, No 8, pp 95-6, Aug 1964.
(through Eng Index, p 2238, 1965).

Descriptors: *Tunnel construction, *Drainage, *Storm runoff, Highways.
Identifiers: *Storm sewers, Houston, Texas.

Techniques described were used in project for Texas Highway Dept. 11 1/2-ft boring machine was pushed 6500 ft passing between 75 sets of proposed freeway columns with tolerance of 18 in. on either side. Tunnel was bored under downtown Houston on sewer project which required 6947-ft long, 8 1/2-ft ID monolithic concrete storm sewer to carry drainage water from depressed section of Highway 59 near center of city.

024
## COUNTY RAIN-GAGE NETWORK USEFUL IN DESIGN.

A. R. Pagan, and R. Rothenberg.
Civ Eng, Vol 35, No 4, pp 68-9, April 1965.
(through Eng Index, p 2044, 1965).

Descriptors: *Rain gages, Design, *Drainage systems.

Bergen County, NJ, supplements two recording rain gages with 13 nonrecording gages read and reported by unpaid volunteers. Small plastic gages are used. Information gained serves to supplement data from U S Weather Bureau for design of drainage structures. Readings in one case proved unusual rainfall in small area and indicated no need for additional facilities.

025
## DOUBLE-BARRELED CLAY-PIPE SEWER.

Lyall A. Pardee.
Amer City, pp 82-83, Dec. 1966.

Descriptors: *Sewers, *Construction, *Velocity, *Corrosion, Design.
Identifiers: Los Angeles, Calif.

A sewer line consisting of two 42 in. clay pipelines running parallel in a common trench reinforced with concrete bedding cradles was designed to solve a corrosion problem in the Los Angeles area. It replaced 7,838 ft. of a reinforced concrete pipe sewer lined with clay plates that was subject to acid attack. The section replaced was part of a gravity line following a steep grade. A combination of the high-velocity flow and $H_2SO_4$ concentration caused corrosion of the concrete at a rapid rate. Design and construction of the new clay pipeline are briefly discussed.

026
### FLOW MEASUREMENT.

V. C. Parker.
La State Univ - Eng Res Sta - Bull 89, pp 116-27, 1967.
(through Eng Index, p 88, Feb 1968).

Descriptors: *Flow measurement, *Flowmeters, Weirs.

Measurement of water and waste-water flow with rate-of-flow meters and quantity meters is described. Design and application of rate-of-flow meters discussed includes variable-head, variable area-constant head, electromagnetic, and sonic velocity meters. Rough field measurements; features of rectangular, V-notch, trapezoidal, parabolic notch, and broad-crested weirs are reviewed.

027
### THE SYSTEMATIC ERROR IN RAINFALL MEASUREMENT.

J. C. Rodda.
Inst Water Eng J, Vol 21, No 2, pp 173-177, March 1967.

Descriptors: *Rain gages, *Standards, Rain.

Various methods for overcoming the effect of wind on the amount of rain collected by a rain gage are discussed. It has been found that a rain gage at ground level gives the measurement approaching closest to the real rainfall, but this is still not the real solution to the problem. No absolute standard for rainfall measurement is yet available, as there is for stream flow, and it appears to the author that only a small amount of progress is possible without one. In the past a simple rule has been adopted -- that the gage giving the largest catch is the best. The author feels that this cannot be sufficient justification for a gage in the future; neither can the use of a particular gage for 100 years be used as an adequate reason for continuing to use it.

028

RADAR ESTIMATION OF RAINFALL.

A. P. Ryan.
J Hydrol, New Zeal, Vol 5, No 2, pp 100-110, 1966.
(through Eng Index, p 2279, 1967).

Descriptors: *Instrumentation, *Rainfall intensity.
Identifiers: *Radar measurement, Calculations.

By calibration of equipment, power back-scattered to radar by precipitation can be measured. Power back-scattered depends on reflectivity of precipitation, which in turn depends on form of drop-size distribution. Rainfall rate is also function of drop size distribution, and empirical relationship exists between reflectivity and rainfall rate. Using this relation, measurements of received power permit estimate of rainfall rate. Trials conducted overseas suggested that accuracy of factor of two can be achieved with suitable equipment on all occasions.

029

GAGE FOR CONTINUOUSLY MEASURING RATE OF RAINFALL.

R. A. Semplak.
Rev Sci Instrum, Vol 37, No 11, pp 1554-8, Nov 1966.
(through Eng Index, pp 2278-9, 1967).

Descriptors: *Rain gages, Instrumentation.
Identifiers: *Calculations.

In gage, water flows through channel type capacitor which is coupled to oscillator, thus frequency of output voltage changes with rain rate. Calibration curve can be expressed mathematically as sum of two exponentials. 100 gages were fabricated and calibrated, and statistics of these calibrations are presented. Based upon measured data, capacitance rain gages are found suitable for situations where continuous rainfall rate data are desired. Output of gage is in form readily adapted for computer reduction.

030
AUSTRALIA DEVELOPS NEW SCIENTIFIC EQUIPMENT TO ASSESS WATER RESOURCES.

I. Stuart.
Water Water Eng, Vol 70, No 850, pp 515-17, Dec 1966.
(through Eng Index, p 2278, 1967).

Descriptors: *Rain gages, Instrumentation.
Identifiers: Australia.

Tilting bucket rain gage was developed and manufactured by Rimco, Melbourne. Bucket, housed in standard 8 in. gage, tilts every time 0.01 in. of rain falls on it and tilting sends out electrical impulse which may operate counter located at gage or may be recorded on charts or tape either at gage or at distance. In this gage bucket is gold-plated to reduce surface tensions and to help water run more easily.

031
TV INSPECTION OF SEWERS IMPROVES REPAIR PROGRAM.

H. T. Thornquist.
Public Works, p 73, Feb 1966.

Descriptors: *Sewers, *Equipment.
Identifiers: *Sewer inspection.

A miniature TV camera (used to inspect sewers 15 ins. and smaller in diameter in Seattle, Wash.) is described in detail. Procedure for inspection is also described. An average day's inspection covers 1,200 ft. of sewer at an average cost of 19 cents/ft. The TV inspection has made it possible to extend the program of schedules repairs. A savings of approximately 1/3 is estimated when repairs can be scheduled on a routine basis.

032
RAINFALL RECORDERS-COMPARISON OF DIFFERENT TYPES.

H. W. Underhill.
Int Ass Sci Hydrol - Bull, Vol 11, No 3, pp 50-5, Sept. 1966.
(through Eng Index, p 2279, 1967).

Descriptors: *Rain gages, Instrumentation, Siphons.

A comparison was made of available recording rain gages. Practical experience with certain of these instruments showed that points of design which are of particular interest are clock mechanisms, siphoning time and frequency, tipping time and frequency, internal constrictions, dribbling siphon and verticality of pen travel.

033
ELBOW METER MEASURES FLOW.

P. A. Vesilind, and F. E. McJunkin.
Public Works, Vol 98, No. 12, pp 80-81, Dec 1967.
(through Eng Index, p 76, July 1968).

Descriptors: *Flow measurement, *Flowmeters, *Sewer hydraulics.

Elbow meter used for measuring flow rate of water in piping systems is described. Any elbow in system may be used and it is not necessary to disassemble piping to install meter. Elbow may be in any position-horizontal or vertical. Pipe must be flowing full, however, during calibration and operation.

034
AUTOMATIC MOBILE SAMPLING AND GAGING UNIT.

R. B. Weidner, S. R. Weibel, and G. G. Robeck.
Public Works, Vol 99, No 1, pp 78-80, Jan 1968.
(through Eng Index, p 235, Aug. 1968).

Descriptors: *Storm runoff, *Sampling, *Instrumentation, Automatic control.
Identifiers: *Urban drainage, *Urban hydrology.

Unit for sampling storm-water runoff from various environments on time-proportioned or flow-proportioned basis was developed by Cincinnati, Ohio, Water Research Laboratory to facilitate urban storm-water runoff studies. Operation of sampler is dependent on sufficient amount of rainfall to start electrical and cooling systems, and predetermined amount of runoff to activate sampling section.

035
SEWER DEPTH OF FLOW DETERMINATION.

Robert C. Wilging.
Water Sewage Works, Vol 109, 103, March 1962.

Descriptors: *Sewers, Pumping, Manholes, *Flow measurement, Storm runoff.
Identifiers: Storm sewers, *Capacity.

A procedure to determine the present sewer capacity available to receive pumped sewage from adjacent areas is described. Sticks, one by one in., grooved on one side and provided with glass vials were placed in selected sewer manholes. Appropriate numbers of vials, regularly checked, provided information of the maximum flow occurring in the period between readings. Information on the influence of rainfall on the flow of sewers in certain areas not served by storm sewers was collected. The information obtained helped to place pumped sewage in areas where sewers were not overloaded even after heavy rainy conditions.

036

PRELIMINARY GUIDANCE FOR THE CALCULATION AND DESIGN OF STORM-SEWAGE OVERFLOWS IN COMBINED SEWAGE SYSTEMS.

Abwassertechnische Vereinigung, 1962. 26p.
(through Water Pollut Abstr, Vol 40, No 2, p 66, Feb 1967).

Descriptors: *Overflow, Rainfall-runoff relationships, *Design.
Identifiers: Storm sewers, *Combined sewers.

Based on existing information on rainfall and run-off in sewerage systems, preliminary measures are suggested for the calculation and design of storm-sewage overflows by determining the critical intensity of rainfall at which an overflow first occurs which is illustrated by nomograms. This method of calculation is not as straightforward as the existing dilution process but it has the advantage that predictions can be made on both the frequency of operation and the duration of the overflow. It is these criteria which determine the state of pollution in the receiving water and permit a uniform and even treatment of the storm-sewage overflow in a cross section of the channel. This confirms the usefulness of this method, since heavy rainfall in sewerage systems can be retained, thus reducing the polluting load on the receiving water.

037

KENT SEWERAGE WORKS FOR 9000 PEOPLE.

Munic Eng, Vol 142, p 1803, 1965.
(through Water Pollut Abstr, Vol 39, No 12, p 410, Dec 1966).

Descriptors: Overflow, Storm runoff.
Identifiers: *Storage tanks.

A description is given of improvements planned by Eastry R.D.C., Kent, to the sewage system for St. Nicholas-at-Wade, Monkton and Minster. The existing treatment plant at Minster, which provides complete treatment by biological filtration, is to be enlarged to deal with a dry-weather flow of about 300,000 gal per day. Storm-water tanks will receive flows of from three to six times the dry-weather flow.

# Section II

# OVERFLOWS AND REGULATION DEVICES

19-A

038
SKIPTON-SILSDEN SEWERAGE FINISHED AHEAD OF SCHEDULE.

Munic Eng, Vol 140, p 1344, 1963.
(through Water Pollut Abstr, Vol 38, No 8, pp 271-2, Aug. 1965).

Descriptors: *Storm runoff, *Overflow, Sedimentation, Weirs.
Identifiers: Storage tanks.

In a recently completed joint sewerage scheme for Skipton rural district and Silsden urban district, Yorks., all the sewage from the area will be conveyed to the Keighley disposal works by an extension of the Keighley sewers up the Aire valley. Six small sewage works will be abandoned, but at Silsden and Stelton storm water will overflow to sedimentation tanks at the old works before discharge to the river Aire. There are also five overflow weirs on existing sewers with direct discharges to the nearest watercourse. A pumping station on the site of the Kildwick works will pump sewage from Farnhill and Kildwick across the river Aire by a rising main to join the main sewer.

039
NEWTHORPE, NOTTS., SEWAGE DISPOSAL WORKS.

Surv Munic City Eng, Vol 130, No 3923, pp 18-19, 55, 1967.
(through Water Pollut Abstr, Vol 41, No 7, p 318, July 1968).

Descriptors: Storm runoff, Overflow.
Identifiers: *Storage tanks.

A description, with a flow diagram of treatment facilities and a map of the sewerage area involved, is given of new works to be constructed jointly by Basford R.D.C. and Eastwood U.D.C., Notts. A new sewage works at Newthorpe, designed to treat a flow of 18 m.g.d. by biological filtration with recirculation of effluent, will replace 7 existing works; flows in excess of 18 m.g.d. will pass to 3 storm-water tanks. Primary sludge will be treated by Paxman sludge concentrator units, and humus sludge will be returned to the main inlet.

040

## RELIEVING OVERLOAD ON TAMWORTH SEWAGE WORKS.

Surv Munic City Eng, Vol 129, No 3905, p 59, 1967.
(through Water Pollut Abstr, Vol 41, No 4, p 172, April 1968).

Descriptors: *Overflow, Storm runoff, Irrigation, Sewage lagoons.

At Tamworth, Staffs., as an interim measure until new works are constructed, effluents from the filters and sedimentation tanks, as well as storm-sewage overflows, are collected in a 150,000-gal lagoon and distributed on to 44 acres of grassland by spray irrigation. The irrigated area is divided into 3 plots, and an 8-week resting period is allowed for each plot.

041

## PVC SEA OUTFALL IN HUNSTANTON SEWAGE SCHEME.

Surv Munic City Eng, Vol 128, No 3876, pp 22-24, 1966.
(through Water Pollut Abstr, Vol 40, No 9, p 404, Sept 1967).

Descriptors: Outlets, Storm runoff, *Overflow, *Pumping, Automatic control, Plastic pipes.

An illustrated description, with a plan of the outfall pumping station, is given of the installation at Hunstanton, Norfolk, of a 10-in. diameter polyvinylchloride submarine outfall 0.5 mile long, consisting of 20 ft. lengths of pipe with acetone cement joints. Subsidiary pumps convey crude sewage to the outfall pumping station; at low tide and normal rates of flow the outfall conveys the sewage under gravity, but at high tide or for high rates of flow the pipeline becomes surcharged and the outfall pumps operate automatically when an overflow sump fills. Provision is made at the pumping station for comminution, the disintegrator being controlled automatically by a lunar clock to operate when the tide is ebbing. Flows in excess of 4·5 times the dry-weather flow are discharged through a separate storm-sewage outfall, a cast-iron pipe extending to the mid-tide mark.

042
### NEW SEWAGE WORKS COMMISSIONED AT LEICESTER.

Surv Munic City Eng, Vol 124, No 3773, pp 25-27, Sept. 26, 1964. 5 fig.
(through Public Health Eng Abstr, Vol 45, No 2-3, pp 70-1, Feb-Mar 1965).

Descriptors: *Overflow, *Storm runoff, Weirs, Pumping.
Identifiers: Storage tanks.

These works are designed for a dwf of over 20 million gal and are capable of extension to treat 22 1/2 million gal. On reception, sewage passes through screens and detritors, screenings being returned to flow through disintegrators; washers clean the grit, which is then pumped to a tip at the edge of the works. A weir overflows storm water in excess of 85 million gal/d direct to the River Soar; the residual flow is lifted 12 ft by 6 centrifugal pumps to permit gravitation through the works. Two of these pumps, each of which has a capacity of 7,500 gal/min, are driven by variable-speed motors controlled by electrodes in the pump well, which allows for changes in flow. Two 24-in. diesel-driven pumps are used for pumping to the storm water tanks.

043
### CHICAGO STUDIES PLAN FOR CONTROLLING COMBINED SEWER OVERFLOWS.

Water Sewage Works, Vol 113, pp 235-36, July 1966. 2 fig.
(through Public Health Eng Abstr, Vol 47, No 1, p 30, Jan 1967).

Descriptors: *Overflow, Storm runoff, Treatment.
Identifiers: Storage tanks, Chicago, Ill., *Combined sewers.

A plan is outlined to temporarily store storm water from overloaded and overflowing combined sewers in subterranean chambers and to later treat the polluted water before its discharge into waterways.

044

### METHOD OF AND MEANS FOR DEALING WITH STORM-WATER OVERFLOWS IN SEWERS AND LIKE DRAINAGE SYSTEMS.

Longwood Engineering Co, Ltd.

Brit Patent 1,023,311.
(through Water Pollut Abstr, Vol 41, No 3, p 114, March 1968).

Descriptors: *Storm runoff, *Overflow, *Sewers, *Drainage systems, Outlets.
Identifiers: *Suspended solids.

The equipment claimed for dealing with storm-sewage overflows in sewerage and other drainage systems comprises a bay fitted with a trough or channel which has walls of unequal height and a mouth covered with a filter screen which can be cleaned by a rake or rakes rotating in the direction of flow of water through the bay. Under normal conditions of flow, water passes through the bay direct to the foul sewer, but under storm conditions the increased flow causes a build-up of pressure in the bay so that water and floating trash flows over the lower wall of the trough and through the screen to the storm-sewage outlet; trash is swept from the screen by the rake(s) over the higher wall into a trash pit and then to the foul-sewer.

045

### TECHNICAL COMMITTEE ON STORM OVERFLOWS AND THE DISPOSAL OF STORM SEWAGE.

Ministry of Housing and Local Government.

H M Stationery Office, London, 1963. 16 pp.
(through Water Pollut Abstr, Vol 39, No 1, p 15, Jan 1966).

Descriptors: *Storm runoff, *Overflow, *Discharge(water), Sewage treatment, Design.
Identifiers: *Suspended solids, *Storage tanks.

In the interim report of the Technical Committee which was set up in May 1955 to study and report on storm overflows and the disposal of storm sewage, present practice in the discharge of storm sewage is reviewed; investigations are reported on storm water in 3 drainage areas, Northampton, Brighouse, and Bradford, on the use and operation of storm tanks at sewage works in Tunbridge Wells and Stoke-on-Trent, and on the characteristics of different types of storm overflow; and preliminary conclusions are drawn, particularly with regard to the volumetric setting of storm overflows, the design of overflows to reduce pollution (by providing storage for the first flush of storm sewage and minimizing the amount of floating and heavy-solid polluting material in the overflowing sewage), and the treatment of storm sewage at the sewage works. It is recommended that each sewerage authority should review existing arrangements for the disposal of storm sewage, and the information required in making this assessment is listed.

046
THEORETICAL CONSIDERATION OF SIDE WEIRS AS STORM WATER OVERFLOWS.

P. Ackers.
Inst Civ Eng Proc, Vol 6, pp 250-69, Disc, pp 328-43, Feb 1957. 24 ref.

Descriptors: *Overflow, *Weirs, *Storm runoff, Spillways, Discharge (water), *Velocity.

Combining Bernoulli's theorem and weir discharge formula, equation for water profile at side spillway can be derived, making allowance for variation in channel velocity. Weir coefficient, velocity variation and extent of draw down are considered in relation to G. S. Coleman and D. Smith's results and simplified design formula are given. Insertion of dip plates may reduce discharge if clearances are small.

047
HYDRAULIC DESIGN OF STORM SEWAGE OVERFLOWS INCORPORATING STORAGE.

P. Ackers, A. J. M. Harrison, and A. J. Brewer.
Inst Munic Eng J, Vol. 95, No. 1, pp 31-7, Jan 1968. 11 ref.
(through Eng Index, p 242, Aug 1968).

Descriptors: *Overflow, *Hydraulic design, Weirs.
Identifiers: *Storage tanks, Capacity.

Consequences of designing storm overflows to spill all discharges over set value, regardless of dynamic behavior of storm flow, are considered. It is concluded that it is desirable to avoid spilling first part of storm wave and method of calculating its volume is presented. Necessary volume of storage tank to contain flush downstream of overflow weirs is considered. Equations describing rate of rise of level in tanks of retangular and circular cross-sections are solved for case of uniformly increasing rate of inflow within range of overflow settings. Design example is given on calculation of volume of tank for overflow.

048

## LABORATORY STUDIES OF STORM OVERFLOWS WITH UNSTEADY FLOW.

P. Ackers, A. J. M. Harrison, and A. J. Brewer.
Paper presented at the Symp on Storm Sewage Overflows, May 1967. Sponsored by the Inst Civ Eng.

Descriptors: *Storm runoff, *Overflow, *Weirs, *Stilling basins, *Model studies, Instrumentation, Water pollution, *Chemical analysis.
Identifiers: *Suspended solids.

Model of four types of typical overflows: 1) a low side weir, 2) a stilling pond, 3) a vortex with central spill, and 4) a storage overflow with high side weir, were tested at two pipe slopes, 1:500 and 1:100. The model overflows were installed in turn at the downstream end of the pipe. The salinities of the base flow, the spilled water and water passed to treatment were measured by electrical conductivity meters. Suspended and floating materials were introduced into the pipe by screw-feed injector, heavier material being put in by hand upstream. Solids were collected by sieves. The tests were divided into two categories: a) those investigating the discharge of dissolved pollution and b) those studying the behavior of bed load and suspended and floating solids. Each structure was first tested with saline-base flow and fresh-water storm waves of 1, 2, 3, and 4 mins. duration. Recorder charts were analyzed for each structure and the duration of each test in turn, to obtain the discharge time curves shown. The proportions of pollutants spilled to the wave duration are shown by graphs as well as the average concentrations of pollutants in the spill as proportions of a base flow concentration each for salt, polystyrene, bakelite, polythene, and polythene with scum boards.

049
AUTOMATIC CONTROL OF PUMPING INSTALLATIONS.

I. M. E. Aitken, and R. A. F. Craven.
Paper presented at Effluent and Water Treatment Convention,
London, 1965. 10 pp.
(through Water Pollut Abstr, Vol 38, No 10, p 344, Oct 1965).

Descriptors: *Pumping, Automatic control, *Overflow.

In discussing the application of automatic control devices in sewage pumping stations, the authors describe and give a schematic diagram of a single-range control system in which two electrode probes in the inflow-reception sump are used in conjunction with a simple program controller to control the operation of a number of single-speed pumps of different ratings which can be brought into service in different combinations. The same system can also be used to adjust the rate of pumping in relation to the amount of storm-water overflow and to control the rate of pumping in the recirculation of effluent at sewage works. The basic principles of the system are also applicable when other level-sensing devices are used instead of the electrode probes in the reception sump.

050
PERMISSIBLE WATER POLLUTION AT COMBINED SEWER OVERFLOWS.

G. Akerlindh.
Sewage Works J, Vol 21, No 6, p 1059, 1949. 19 ref.

Descriptors: *Overflow, *Water pollution, Dissolved oxygen, Coliforms.
Identifiers: *Combined sewers.

By plotting the hours duration of storm-water overflow against allowable D.O. content and coliform density in the stream, on double log diagrams, the author presents a method for estimating the permissible storm-water overflow in a receiving body of water.

051
STORM WATER OVERFLOWS. THE USE OF SIPHONS AT IPSWICH.

R. N. Barrett.
Inst Munic Eng J, Vol 85, pp 33-42, 1958.

Descriptors: *Overflow, *Siphons, Weirs, *Storm runoff.
Identifiers: *Combined sewers.

The author describes experiences at Ipswich in the design and operation of siphon overflows for removal of excess storm water from combined sewerage systems. Siphon overflows are considered to have certain advantages over the more commonly used side-weir overflows.

052
DESIGN OF UNDERWATER STORM WATER OVERFLOW STORAGE SYSTEM.

J. S. Blossom.
Piping Air Cond, Vol 40, No 4, pp 126-30, April 1968. 10 ref.
(through Eng Index, p 239, July 1968).

Descriptors: *Design, *Storm runoff, *Overflow, Runoff, Outlets, *Flow measurement, *Instrumentation.
Identifiers: *Storage tanks, *Combined sewers, *Interceptor sewers, *Suspended solids, *Capacity.

Sequence of operation of underwater storm water overflow storage system using flexible tanks is described. Combined sewer carries runoff from drainage area. Dry weather flow connection carries storm water to river outfall. Diversion structure of sewer diverts flow to storage system. Incorporated in structure is flume to measure flow. Suspended solids analysis of overflow. Capacity analysis of underwater storm water overflow storage system, based on 11 yr of rainfall data.

053
### DESIGN AND OPERATION OF LOW-HEAD SELF-PRIMING SIPHONS.

C. D. C. Braine.
Surv, Vol 116, pp 1141-43, Nov 2, 1957.

Descriptors: Design, *Siphons, *Weirs, *Storm runoff, *Overflow, Sewers, Discharge (water).

Small self-priming siphons have advantages over weirs for storm water overflows and other water level regulating uses in sewers and canals. They are as a rule cheaper than weirs provided that at least one foot of head is available. The siphon is more flexible in operation than a weir. Siphons can be made very sensitive, and by admitting air in limited quantities, their discharge can be varied considerably. Also installations of a battery of several siphons permits flexibility of discharge. Nine illustrations of siphon designs are given. Self-priming of a siphon is achieved by allowing a sheet of water to flow over the whole width of the crest so that as the sheet falls it strikes the opposite wall of the siphon. The falling sheet of water entrains air with it and carries it down to the outlet so that the siphon very quickly primes. A formula for estimating the discharge of circular siphons flowing full is given.

054
### DRAW-DOWN AND OTHER FACTORS RELATING TO DESIGN OF STORM-WATER OVERFLOWS ON SEWERS.

C. D. C. Braine.
Inst Civ Eng J, Vol 28, No 6, pp 136-63, April 1947.

Descriptors: *Storm runoff, *Overflow, Sewers, *Siphons, *Stilling basins, *Drawdown, Design.

Calculations for critical depth and drawn-down are discussed. Storm water overflows of restricted flow are described, as well as stilling pond and siphon types.

055

OPERATING EXPERIENCES AT SWINDON, 1962 - 1967.

W. F. Carmichael.
Paper presented at Mtg of Inst Water Pollut Contr, Central Southern Branch, Mar 27, 1968.

Descriptors: Storms, *Automatic control, Sewage treatment, *Equipment, *Overflow, *Storm runoff.
Identifiers: *Storage tanks, Capacity.

The sewage plant, its equipment, and operation are described. In dry weather, only one screen is used. It is operated by a time-clock for five minutes in every fifteen. In time of storms both screens are operated continuously by hand. There are 2 No. detritors with vortex grit washers. Both detritor scrapers, air lift pumps and vortex washers are operated continuously. Three stormwater overflows are controlled by an automatic penstock and standing wave flume. All overflows discharge into a single circular stormwater tank 200 ft. in diameter and of 2 mil. gal. capacity. Effluent from this tank overflows onto 11 acres of underdrained stormwater land.

056

STORM SEWAGE SEPARATION BY HELICAL MOTION.

C. H. Dobbie, and J. W. Wielogorski.
Surv Munic City Eng, Vol 127, No 3839, pp 141-159, 1963.
(through Water Pollut Abstr, Vol 40, No. 4, p 165, April 1967).

Descriptors: *Storm runoff, *Overflow, Weirs, *Model studies.

An improved storm-sewage overflow is proposed, incorporating bends in the channel which produce helical flow, separating heavier materials and allowing the less-polluting liquid to flow over a weir along the outer wall of the channel. Tests are being conducted on a hydraulic model, which is illustrated, and it is hoped to incorporate this type of overflow in an existing sewerage system soon.

057

### MODEL INVESTIGATIONS OF DIFFERENT TYPES OF STORM-WATER OVERFLOWS AND THEIR EFFECT ON THE SEWAGE WORKS AND THE RECEIVING STREAM.

B. Erfmann.
Technisch - Wissenschaftliche Mitt, No 3, 1960.

Descriptors: *Overflow, *Storm runoff, *Water pollution, *Weirs, Design, *Model studies.

Investigations with a model plant are described into the effect of the design and position of storm-water overflows on the distribution of polluting matter between the sewage works and the stream. Weir designs which ensure that the greatest possible amount of polluting matter passes to the sewage works are discussed.

058

### THE PERFORMANCE OF STILLING PONDS IN HANDLING SOLIDS.

M. R. Frederick.
Paper presented at the Symp on Storm Sewage Overflows, May 4, 1967.
Sponsored by the Inst Civ Eng.

Descriptors: *Stilling basins, Storm runoff, Discharge (water), *Weirs, Design, Siphons, Equipment.
Identifiers: *Suspended solids, Capacity.

The total capacity of a stilling pond may be sufficient to prevent dischage in storms of short duration and moreover, the solids dislodged from the sewer in the early part of the storm flow may be retained and passed into the sewer when flow subsides. The behavior of gross solids was investigated to determine how the pond may be proportioned to minimize the quantity of solids in the discharge. The essential features of the type of stilling pond under consideration are illustrated, as well as the form and action of the air-regulated siphon and the water circuit. The experiments were arranged first to establish a valid technique on a pond of specified geometry, and then to use this technique to examine and develop geometrical shapes which appeared to offer the possibility of high efficiency. Tests were made to compare the performance of a rectangular stilling pond with that of a side weir and that of a fan-shaped chamber with an end weir. The rectangular design is shown to be superior in its handling of gross solids. From the tests and with $VC^{1/2}D/U$ as a parameter, recommendations are given for design dimensions of: a) pond size, b) siphon type and position, c) scum board size, and d) invert shape. The efficiency of a pond thus designed may be obtained from given curves.

059
STORM FLOWS FROM COMBINED SEWERAGE SYSTEMS IN THREE AREAS.

A. L. H. Gameson, R. N. Davidson, and J. M. Threlfall.
Inst Public Health Eng J, Vol 64, pp 182-208, 1965.
(through Water Pollut Abstr, Vol 39, No 10, p 340, Oct 1966).

Descriptors: *Storm runoff, *Overflow, Discharge (water).
Identifiers: *Combined sewers, *Calculations.

Results are given of investigations at Northampton, Brighouse, and Bradford on the frequency and duration of operation of storm-sewage overflows on combined sewerage systems and on the volume of storm sewage discharged, since this knowledge is required when determining the optimal setting for an overflow. From the results, equations have been developed which were found to fit not only the data from these three systems but also those from a partially-separate system at Luton; some examples are given of the use of the equations to determine the setting so that the overflow would operate only on a certain number of occasions per year or that the average yearly discharge should be a certain percentage of the rainfall.

060
USE OF STORM WATER OVERFLOWS ON SEWERS: THEIR DESIRABILITY, AND RISKS OF POLLUTION.

J. H. Garner.
Surv, Vol 108, p 131, 1949.

Descriptors: *Overflow, Sewers, *Water pollution, *Storm runoff.

Considerable pollution of surface waters is caused by sewage discharged from storm water overflows. The author considers that in many cases improvement could be effected by reducing the number or altering the position of overflows and in some instances larger volumes could be treated at the sewage works.

061

## STORM-WATER CONTROL BY SIPHON SPILLWAYS AT EARLSWOOD SEWAGE WORKS, REIGATE.

J. M. Harwood.
Inst Sewage Purif J, Pt 2, 1960.

Descriptors: *Siphons, *Spillways, *Storm runoff, *Weirs.

At the Earlswood sewage works of Reigate, Surrey, storm water was formerly separated by means of a normal side weir following the line of the main inlet channel, but this was not satisfactory. It was therefore decided to install a series of siphon spillways. The reasons for this decision are listed, and details of the installation are described.

062

## TESTING AND CALIBRATION OF STORM OVERFLOW CONTROL PIPES.

K. Hutton.
Contract Rec, Vol 70, No 23, p 13, 1959.

Descriptors: *Stilling basins, *Overflow, *Flow control, *Storm runoff, Discharge (water), Velocity, *Instrumentation.
Identifiers: *Suspended solids.

The stilling pond overflow pipe, which provides the most efficient means for the separation of 6 times the dry weather flow from storm water flows, and for removing suspended solids from storm water, is described, and the one in use at Mixenden is presented diagrammatically. Tests carried out at Halifax on this type of overflow and its calibration are given in detail, and show the variation between discharges allowed for in design and those met with in practice. Equations are derived for the determination of several factors including the hydraulic gradient, velocity head, and friction loss. From the studies so far carried out, it was concluded that the stilling pond is the best type of storm overflow at present in general use.

063
TESTS ON A MODEL STILLING POND WITH SIPHON OVERFLOW.

P. M. Jarrett, H. F. Griffiths, and E. Markland.
Civ Eng Public Works Rev, Vol 59, 346, 1964.

Descriptors: *Stilling basins, *Model studies, *Siphons, *Overflow, Water pollution control, *Storm runoff, Weirs, Instrumentation.
Identifiers: *Suspended solids.

The use of stilling ponds is considered to be the most effective way of reducing pollution from storm-water overflows, since an efficient stilling pond should retain much of the solid matter discharged during the first flush of storm-water and subsequently pass it down the sewer as the level falls. The authors have carried out preliminary tests on a model stilling pond equipped with a siphon in place of the usual overflow weir; the results, which are discussed briefly, warrant more detailed investigations, using suspended particles of various sizes over a continuously graded spectrum of specific gravity, to establish optimal proportions for stilling ponds with siphon overflows.

064
[CRITICAL OBSERVATIONS ON THE HYDRAULIC DIMENSIONING OF STATIONARY RAIN OVERFLOWS]. Kritische Betrachtungen zur hydraulischen Bemessung fiststehender Regenüberlaüfe (in German).

J. Jehne.
Wasserwirtsch - Wassertech, Vol 17, No 4, pp 121-127, April 1968.

Descriptors: *Overflow, *Hydraulics, *Storm runoff, Dilution, Sewage sludge.

After presenting the weak points of the notion "dilution" in hydraulic measurement of stationary rain overflows, the author recommends the specific content (related to the unit of water amount) of one or more components (specific load) as the criteria for the admissible load of the receiving stream. The developed formulas permit: the calculation of the expected upper limit value of the specific load and the calculation of the overflows; the numerical expression of the conditions in case of more overflows from the same collector; and exact information about the effects of sludge whirl-up in the collector or about the imperfect mixing of the individual incoming and outgoing amounts. The influence on the load can be expressed by the (temporary or continuous) magnitude change in one of the load determining factors.

065

### A CONTRIBUTION TO HYDRAULIC CALCULATIONS ON LATERALLY-BAFFLED STORM-SEWAGE OVERFLOWS.

G. J. Kallwass.
Thesis, Technische Hochschule, Hannover, 1964.
(through Water Pollut Abstr, Vol 41, No 1, p 17, Jan 1968).

Descriptors: Design, *Hydraulic design, *Overflow, *Storm runoff, Weirs, Discharge (water).
Identifiers: *Calculations.

In connection with the design of storm-sewage overflows, pilot-plant experiments were carried out at the Institut für Hydromechanik, Hannover, to calculate the conditions of flow before and after passage over a weir at varying angles, taking into consideration geometrical characteristics when calculating the discharge after a peak load. The equation used for the calculation is based on those for overflowing weirs.

066

### [THROTTLE MEASURING DEVICE OF RAINWATER OVERFLOWS]. Drosselblenden am Regenüberlauf. (in German).

G. J. Kallwass.
Gas Wasserfach, Vol 109, No 6, pp 150-155, 1968.

Descriptors: *Storm runoff, *Overflow, Outlets, *Weirs, Flow measurement, *Instrumentation, *Model studies.

Rainwater overflows with high weirs and throttled outlet systems have recently been used to limit the load of receiving streams. The infeed system lying above the weir limits the duration and frequency of the overflow. The efficiency of the throttle line is determined by the diameter, the length, and the slope of the bottom of the line. Because of high costs it is not advisable to undertake any reconstruction of the throttling line or to construct it behind already existing non-throttled rainwater overflows. The same holds true for repairs of errors caused by incorrect calculations. In such cases, use is made of the throttle stop. Located above the canal network outlet, the stop closes the flow in the upper infeed section of the network. A method is described to calculate one-sided rainwater overflows with throttle stops. This method can be applied in almost all cases in which, in the infeed portion, a normal streaming run-off ($t_N > t_{gr}$) is observed or in which, in the case of a shooting normal run-off($t_N < t_{gr}$), a streaming run-off above the weir can be forced ($S_N < S_o$). The parameters required for the calculations were obtained on models with circular pipes. However, they can be applied for other cross sections as well, provided the same conditions are observed.

067
THE STORAGE AND DISCHARGE CAPACITIES OF SEWERAGE AND THE OPERATING FREQUENCY OF STORM OVERFLOWS: DUTCH METHOD OF CALCULATION.

A. C. J. Koot.
Paper presented at the Symp on Storm Sewage Overflows, May 4, 1967.
Sponsored by the Inst Civ Eng.

Descriptors: *Discharge (water), *Storm runoff, *Overflow, Pumping.
Identifiers: *Capacity, Surface permeability, *Calculations.

This system is based on the principle that a system must be filled before diluted sewage is discharged into the surface water. It assumes that part of the precipitation received in the impervious area: a)flows into the sewerage system; b)is discharged or pumped off near the end of the main sewer; and c)may be discharged into the surface water via storm overflows. Calculations are restricted to those for the static storage capacity. The figure calculated is the capacity of the sewer pipes between the top of the lowest overflow(s) and the highest water level in the sump of the pumping station, or level at discharge. The available discharge capacity is considered, with schematic representations for both flat and sloping areas shown. A scatter diagram of the amount of rain in mm's plotted against the duration of the rain in minutes for 195 showers of more than 7mm. which fell in DeBilt, Utrecht, between 1938 and 1948 is also included. On the basis of the given assumptions, it is possible to determine the approximate number of showers giving rise to overflow of sewage for the 11 year period.

068
THE DESIGN AND EFFICIENCY OF STORM WATER OVERFLOWS IN COMBINED SEWERAGE SYSTEMS.

H. Lohff.
Gesundh Ing, Vol 75, pp 397-9, 1954.

Descriptors: *Overflow, *Storm runoff, *Water pollution, Discharge (water), Design, *Sewage sludge.
Identifiers: *Combined sewers.

The author discusses the problem of pollution of streams by storm water overflows and methods of reducing both the amount of storm water thus discharged and the polluting matter carried. Alterations in the design of the overflow are suggested with special attention to increasing the height of the overflow sill to form a storage chamber where sludge washed from the sewer could collect.

069
LOSS OF SANITARY SEWAGE THROUGH STORM WATER OVERFLOWS.

J. E. McKee.
Sewage Works J, Vol 20, pp 589-90, 1948.

Descriptors: *Storm runoff, *Overflow, *Rainfall intensity.
Identifiers: *Boston, Mass., *Interceptor sewers, *Combined sewers, Capacity.

Data are given on the rainfall at Boston, Mass.; the effect of rainfall on the flow of intercepting sewers of the combined sewerage system, the proportion of sewage in storm water overflows, and the frequency of overflow. It was found that storm water runoff equal in volume to the dry weather flow of domestic sewage was produced when rainfall was 0.01 in/hr. When twice the average dry weather flow was intercepted about 2.7% of the total amount of domestic sewage overflowed. Overflow occurred about 5-6 times/month in the summer. The effects of increasing the capacity of the interceptors on the amount of sewage in the overflow and on the frequency of overflow is discussed.

070
LOSS OS SANITARY SEWAGE THROUGH STORM WATER OVERFLOWS.

J. E. McKee.
Boston Soc Civ Eng J, Vol 34, No 2, pp 55-80, April 1947.

Descriptors: *Storm runoff, *Overflow, *Rainfall intensity.
Identifiers: *Boston, Mass., *Interceptor sewers, *Combined sewers, Capacity.

In contemplating design of intercepting sewers, relation between storm run-off and sewage, and similar problems were studied at Boston, Mass.; data on rainfall and rainfall probability; run-off from low intensity rainfall; relation between run-off and dry weather sanitary flow; duration and extent of sewage overflows; effect of interceptor capacity on frequency of overflow of sanitary sewage.

071

## ONE WAY TO BYPASS A LARGE SEWER.

Charles A. Manganaro.
Water Works Wastes Eng, Vol 1, pp 46-47, July 1964. 3 Photo.
(through Public Health Eng Abstr, Vol 43, p 433, 1963).

Descriptors: *Automatic control, Instrumentation, *Overflow, Design.
Identifiers: *Sewer infiltration.

A unique plug valve designed to permit automatic bypass of an 84 in. trunk sewer has been installed by the Bergen County Sewer Authority in New Jersey. An overflow chamber was constructed over the 84 in. line just before the sewer crosses the Hackensack River. The valve consists of a large circular plate with a continuous circular neoprene gasket riveted to the underside to prevent infiltration of water due to tidal conditions and also to seal against odors when not operating. The cylinder, mounted on the underside of the plate, acts as a buoyant force and the lift is counteracted by the addition of lead ballast into the cylinder. The valve is designed to lift when the gradient of the sewer is 2 in. above the top of the overflow chamber. Side guides set around the cylinder keep the valve centered. Valve stops are mounted above the overflow chamber to prevent the valve from being lifted out of the opening. The complete valve, weighing about 4,000 lb, can be lifted for inspection by means of jacks.

072

## RECONSTRUCTION OF OVERFLOWS.

W. H. G. Mercer.
Paper presented at the Symp on Storm Sewage Overflows, May 4, 1967.
Sponsored by the Inst Civ Eng.

Descriptors: *Storm runoff, *Overflow, Storms, Design.
Identifiers: *Calculations, *Suspended solids.

The policy adopted by the city of Rochdale to accept all liquid trade wastes made it necessary to recalculate the loads on the entire sewage system. This recalculation led to the decision to reconstruct some of the original storm sewage overflows to accept the additional loads. Since a large number were involved, it was decided to reconstruct one overflow on an experimental basis first. Part of the experiment was to determine the conditions when a storm occurred which only just put the overflow into operation. The effect of surcharging the sewer before allowing the overflow to begin was that nearly all floating matter was held back some distance upstream. Matters of public relations undertaken when an overflow in a shopping area was reconstructed are given in detail. Although the work on overflows has formed part of a comprehensive program, the reconstruction of each had its particular problems. Ultimate design was dependent on a number of existing factors, some fixed and some varying with limits. As work progressed, it was observed that: a) a far greater volume of sewage was being passed to the sewage works; and b) the discharge of floating matter to the water courses during storms was decreasing.

073
PRACTICAL DESIGN OF STORM SEWAGE OVERFLOWS.

P. R. Oakley.
Paper presented at the Symp on Storm Sewage Overflows, May 4, 1967.
Sponsored by the Inst Civ Eng.

Descriptors: *Design, *Overflow, *Storm runoff, Hydraulics, Stilling basins, Equipment, *Weirs.
Identifiers: *Suspended solids.

The extent that the ideals of theory can be realized in the practical design of storm sewage overflows is discussed with special emphasis on efficiency and reliability. Two tests of efficiency for storm water overflows are: a) hydraulic performance, and b) separation of suspended solids. Hydraulic efficiency implies that overflow does not commence prematurely and that the base flow does not vary with the rate of overflow. The two possible approaches to efficiency in separation of solids are to use physical methods of restraint or to rely on gravity separation. The relative merits of screening, stilling ponds or vortex action in separation are discussed. Reliability is taken to include safety and convenience in operation as well as the more direct meaning. The structure should be designed for a life in excess of 30 years. Power driven devices are best avoided unless adequate and regular maintenance is assured. Emergency by-pass arrangements should be made. A design of 1937 is illustrated and discussed as well as a high weir type overflow. More opportunity is afforded in designing large overflows on new sections of sewer; one such design is shown. No overflow should be located on sewers less than 18 in. dia. or of maximum flow less than 6 cusecs. For small overflows the storage type are suitable; with larger flows only limited storage is likely to be practicable.

074
MAINTENANCE OF STORM FLOW REGULATORS.

Max B. Phillips.
Sewage Ind Wastes, Vol 31, No 7, p 861, July 1959.

Descriptors: *Storm runoff, *Instrumentation, *Flow control, Maintenance.

A survey was made of cities in the State of Ohio as to the use and performance of regulators. Thirty per cent of the cities reported that regulators were a major problem and a break-down of the kinds of malfunctioning is given. An outline of a workable program of regulator inspection and maintenance is developed.

075
SECONDARY MOTIONS APPLIED TO STORM SEWAGE OVERFLOWS.

T. M. Prus-Chacinski, and J. W. Wielogorski.
Paper presented at the Symp on Storm Sewage Overflows, May 4, 1967.
Sponsored by the Inst Civ Eng.

Descriptors: *Storm runoff, *Overflow, *Design, *Model studies.
Identifiers: *Calculations, *Suspended solids.

A model was used to study the possibility of using the helical flow in short bends as a basis for the design of storm sewage overflows. For a short bend a convenient measure of the intensity of the helix is the angle between the circumferential direction and the direction of flow very near to the bed of the channel. Several expressions were developed to predict the value of this angle. There is evidence that in a bend longer than $\theta=90°$ the intensity of the helix decreases, and that eventually at $\theta=180°$ the direction of water near the bed reverses toward the outer wall. If a relatively short bend is followed by a second of opposite direction, the helix generated in the former suppresses development of the helix in the latter. However, an S channel may be more convenient to use and was therefore investigated. The symmetrical S shape of the channel was chosen so that a number of possible configurations of the relative positions of slots and overflow could be investigated by reversing the channel. Figures are included to show the bed load distribution both with slots closed and opened; the relationship between suspended load and flow through the slot; and the relationship between bed angle in the first bend and Reynolds' number in a semicircular channel. It is concluded that the results of the investigation may be used to design an effective and cheap storm sewage overflow.

076
WASTE TREATMENT PLANT MODIFIED FOR INCREASED SOLIDS LOADING.

A. J. Reisdorph.
Public Works, Vol 96, No 4, pp 113-114, 1965.
(through Water Pollut Abstr, Vol 39, No 8, p 268, Aug 1966).

Descriptors: *Storm runoff, *Overflow, Discharge (water), Sewage treatment.
Identifiers: *Combined sewers, Spokane, Wash.

The primary sewage-treatment plant at Spokane, Wash., has been enlarged to provide adequate treatment for the recently-added load of industrial waste waters (mainly from packing houses). The additional equipment includes a preliminary aeration unit for grease removal, and increased clarifying and digesting capacity. A storm-water overflow device selects the upper and lower strata in the combined sewers, containing comparatively clean water and grit respectively, for discharge direct to the Spokane river.

077
ON MEASUREMENTS OF STORM-SEWAGE OVERFLOWS - A GRAPHICAL METHOD.

L. Schmitz.
Gesundh Ing, Vol 85, p 363, 1964.

Descriptors: *Storm runoff, *Overflow, *Flow measurement.
Identifiers: *Calculations, Bernoulli's theorem.

Owing to the inaccuracy and difficulty of existing methods of calculations for storm-sewage overflows, a graphical method has been developed based on Bernoulli's equation. By this method not only can liquid flow through non-uniform pipes be measured, but with the application of Bernoulli's theorem the difference in pressure between the top and bottom ends of the pipe and/or the required section of such vertical tapered pipe can be calculated. Values for the pressure drop, throat diameter and throat length for a minimum pipe-fall of 0.5 per cent and for the friction coefficient of 0.15 and 0.30 in relation to the volume of flow and the head of water are given. Diagrams and tables together with a worked example support the author's method.

078
MEASUREMENT OF STORM WATER OULETS IN COMBINED SEWERS BY THE THROTTLE-PIPE PROCESS.

L. Schmitz.
Gesundh Ing, Vol 79, p 323, 1958.

Descriptors: *Storm runoff, *Outlets, *Overflow, Weirs, Instrumentation.
Identifiers: *Combined sewers, *Calculations.

After discussing the differences between storm-water overflows in combined sewers and straight vertical-flow weirs, the author gives diagrams for the calculation of storm-water overflows when the following pipe is designed as a throttle pipe.

079
STORM-WATER OVERFLOWS: THE OPERATION AND DESIGN OF A STILLING POND.

D. E. Sharpe, and T. W. Kirkbride.
Inst Civ Eng. Proc, Vol 13, p 445, 1959.

Descriptors: *Storm runoff, *Overflow, *Design, *Stilling basins, *Flow control, Water Pollution, *Model studies.

In designing storm-water overflows, the use of stilling ponds has many advantages as it not only permits comparatively accurate regulation of the flow but also results in less polluting matter being discharged. Model experiments were carried out on the operation of stilling-pond overflows with a view to determining the conditions limiting chamber design and to deriving suitable design standards. The flow patterns within a stilling pond were first investigated and the limiting conditions deduced therefrom are presented in a simple form for design application. The applicability of the results to the performance of full-scale overflows is being studied.

080
### DESIGN, CONSTRUCTION AND PERFORMANCE OF VORTEX OVERFLOWS.

B. Smisson.
Paper presented at the Symp on Storm Sewage Overflows, May 4, 1967.
Sponsored by the Inst Civ Eng.

Descriptors: *Design, *Construction, *Overflow, *Model studies, Outlets, Storm runoff, Rainfall intensity.
Identifiers: *Suspended solids, Calculations.

Using hydraulic models, research was carried out on comparatively small tanks using rotary motion induced by the kinetic energy of the sewage. A considerable increase in the amount of solids concentrated in the foul-water outlet over that due only to gravity was found. The program covered devices with prototype retention times from 20 secs. to 20 min. with energy levels at inlet from 0.05 to 20 ft. lbs./lb. Two full-sized overflow chambers have been built and observed in operation for several years. The model separators tested were of three types. The largest separator is illustrated and described. The results obtained at a 5 min. retention time, with crude macerated sewage having a mean strength of 230 p.p.m. suspended solids, are shown. It was found that a very significant degree of separation took place. To achieve satisfactory conditions of flow many alterations in shape had to be made, in particular a deflecting wall alongside the in-coming sewer. Floating solids were easy to retain by dip-plate. The number of occasions on which the overflow operates per year and the duration of such occasions would give a better criterion for design than any estimate of what should be left in the sewer. A method of design based on statistical analysis of rainfall is given, which enables the designer to choose the size of overflow best suited for any particular site.

081
### THE PROBLEMS OF STORM-WATER OVERFLOWS.

V. Stalmann, and G. Warg.
Gesundh Ing, Vol 81, p 257, 1960.

Descriptors: *Storm runoff, *Overflow, Design, Flow measurement.
Identifiers: *Storm sewers, *Calculations, *Capacity.

The authors discuss calculations of flow in pipes and the dimensions and design of storm-water overflows.

082
THE TREATMENT OF STORM SEWAGE.

B. D. Steele.
Paper presented at the Symp on Storm Sewage Overflows, May 4, 1967.
Sponsored by the Inst Civ Eng.

Descriptors: *Water pollution, *Storm runoff, *Overflow, *Automatic control, Sewage treatment.
Identifiers: *Storage tanks.

A prime objective of the virtual resewerage of an area of about 27,900 acres at Coventry is the elimination of pollution in the river system, which forms the headwaters of the River Avon. The solution lies in the building of Storm Balancing Stations. In time of rain all flows in excess of 3 d.w.f. are spilled off into mechanically scraped circular tanks. Sludge is evacuated to the sewer. The provision of additional tanks or other processes is feasible. The tanks are probably unique in that overflow to the tanks, operation of the scraping mechanism, continuous pumping of sludge, sampling, tank emptying to the sewer and rising main emptying are all automatic. Results are beginning to become available from one station. Conclusions are that if in future a proportion of the flow in a foul sewer may be discharged directly to the river the device for separating the elements must be designed on a more scientific basis, and the solution may lie in the provision of storm balancing tanks.

083
[PROBLEM OF DESIGN OF INTERCEPTING DEVICES WITH OVERFLOW WEIRS IN COMBINED SEWER SYSTEMS]. Au sujet de la disposition à donner aux dèversoirs d'orage dans les reseaux d'égouts. (in French).
Int Ass Hydraul Res, 11th Cong, Leningrad, Vol 2, paper 2.11. 9 p.
(through Eng Index, p 2736, 1966).

Descriptors: *Overflow, *Weirs, *Design, *Storm runoff, Sedimentation.
Identifiers: *Combined sewers.

The problem is considered in relation to transportation of sediment which is kept away from water-course receiving sewer flow. Theory and experiments in laboratory show that laterally designed weir to divert storm water peak flow directly into watercourse is poor design, as it also removes sediment and brings it into river.

084
[HOW TO PLACE STORM SPILLWAY IN COMBINED STORM AND SANITARY SEWER SYSTEM]. Comment disposer un déversoir d'orage sur une canalisation d'égout en système unitaire. (in French).

G. Tison, and V. Vukmirovic.
Rev C, Vol 4, No 1, pp 7-11, 1966.
(through Eng Index, p 2473, 1967).

Descriptors: *Overflow, *Storm runoff, *Design, Sedimentation.
Identifiers: *Combined sewers.

Problem is considered in relation to transportation of sediment which is to be kept away from water-course receiving sewer discharge. Theoretical considerations and laboratory tests show that laterally designed spillways for diverting stormwater peak flow into watercourse did not perform satisfactorily. Improved spillway designs are discussed and experimental results obtained are shown in diagrams.

085
HYDRAULIC ASSUMPTIONS IN CALCULATING STORM-WATER OVERFLOWS.

H. Wagner, and G. J. Kallwass.
Gas Wasserfach, Vol 101, p 660, 1960.

Descriptors: *Storm runoff, *Overflow, *Design, Hydraulics.
Identifiers: *Calculations.

The commonly used methods of calculation for storm-water overflows are not suitable for modern designs. The authors discuss conditions of flow, run-off curves, and the friction coefficient and give a diagram for calculation of flow conditions in different shapes of sewer. Sources of error are considered.

086

### THE EFFECT OF DELAYED DISCHARGE ON THE CALCULATION OF STORM-SEWAGE OVERFLOWS.

G. Warg.
Gas Wasserfach, Vol 107, pp 85-89, 1966.
(through Water Pollut Abstr, Vol 39, No 9, p 303, Sept 1966).

Descriptors: *Overflow, *Storm runoff, Discharge (water), Design, *Hydrographs.
Identifiers: *Calculations, Munich, Germany, Capacity, Surface permeability, *Urban hydrology, Storage tanks.

The author discusses theoretically the effect of delayed discharge of rain water on the design calculations and measurements of storm-sewage overflows and gives a detailed account of the measurements which were carried out in the sewerage system at Munich to evaluate the effects on discharge capacity, intensity and duration of discharge, load on the receiving water, and dimensions of the sewerage system. He suggests the use of a specially-developed hydrograph system to calculate and allow for changes in permeability at peak flows and to assess the maximal area likely to be covered during rain storms. Tables and nomographs which are included can also be used to calculate the effects of delay on design calculations for storm-sewage plants and flood retention basins.

# Section III

# SEWER HYDRAULICS

45-A

087
POLYMER COAGULATORS.

Environ Sci Technol, Vol 1, No 2, p 111, Feb 1967.

Descriptors: *Flow control, Storm runoff.
Identifiers: *Polymers, *Combined sewers, *Capacity.

The research division of the Western Co. is studying the feasibility of adding polymer coagulators to combined sewer-storm lines to enable them to carry greater quantities of sewage during rains. The additives increase fluid flow in pipes by reducing turbulent friction loss. If the method proves feasible, demonstration tests will be conducted in the Dallas-Fort Worth area in mid-1968.

088
AN INVESTIGATION OF HEAD LOSSES AT SEWER MANHOLES.

P. Ackers.
Civ Eng, Vol 54, 1959.

Descriptors: *Manholes, *Head loss, Overflow, Sewers.

The author describes the results of experiments on factors affecting head losses at sewer manholes. It was found that head losses at open invert manholes are small except when surcharge occurs and hatch-box manholes are no better except under surcharge conditions.

089
THE HYDRAULIC RESISTANCE OF DRAINAGE CONDUITS.

P. Ackers.
Inst Civ Eng Proc, Vol 19, 1961.

Descriptors: Sewers, *Flow resistance, *Roughness (hydraulic), *Velocity, *Storm drains, Pipes.
Identifiers: *Storm sewers.

Further details are given of theoretical and experimental studies on the hydraulic resistance of sewers and storm drains, which have been carried out by the Hydraulics Research Station including experiments on salt-glazed, spun concrete and pitch-fiber pipes, both full and partly-full.

The results, given in tables and graphs, show that flow conditions in new sewers are turbulent-transitional and that the eccentricity and spacing of the joints affect the overall roughness. Neither the Crimp and Bruges nor the Manning formulae fit the experimental data and the equation proposed by C. F. Colebrook, and C. M. White is preferred. On the basis of data obtained, roughness values for new sewers are suggested. Under partly-full conditions, proportional velocities follow the theoretical trend, but are lower, indicating an increase in roughness for free-surface flow, the possible cause of which is discussed.

090
TABLES FOR THE HYDRAULIC DESIGN OF STORM-DRAINS, SEWERS, AND PIPE-LINES.

P. Ackers.
Hydraul Res Pap No 4, H M Stationary Office, London, 1963.

Descriptors: *Hydraulic design, *Storm drains, *Sewers, Velocity, *Roughness (hydraulic), *Discharge (Water), Design, Pipes.
Identifiers: *Storm sewers.

To assist in the design of sewers and storm-water drains, this publication contains tabulated data on the discharges and velocities in pipes over a range of diameters (6-96 in.) hydraulic gradients (1 in 10,000 - 1 in 10), and roughnesses ($k_s$ values from 0.0002-0.05 ft.).

091
RAIN DISCHARGE AND SEWAGE SLUDGE.

G. Amberger.
Gesundh Ing, Vol 56, p 298, 1933.

Descriptors: *Storm runoff, *Sewers, *Design, Overflow.

When the sewage flow is so divided that half continues in the same direction, half through a pipe at an angle, then about 97% of the sludge goes through the latter pipe when the angle with the original direction is 30°, about 87% when it is 120°. These data are significant in the construction of plant by-passes to provide for heavy flow resulting from rains so that the richer sewage goes through the plant, the dil. being by-passed to the river.

092

HYDRAULIC DESIGN OF DEPRESSED CURB-OPENING INLETS.

W. J. Bauer, and D. C. Woo.
Nat Res Counc - Highway Res Board - Res Rec, No 58, pp 61-80, 1964.
(through Eng Index, p 2092, 1965).

Descriptors: *Hydraulic design, *Intakes, *Highways, Drainage systems, *Storm runoff.

New hydraulic design curves for depressed curb-opening inlets used in highway drainage systems were developed from experimental data. Curves cover considerable range of practical conditions and also allow direct comparison of effect of size of depression to efficiency of inlet. Sump condition is included that refers to condition that inlet is located at low point of sag vertical curve. Application of curves is presented.

093

DESIGN, CONSTRUCTION AND OPERATION OF SEWER OUTFALLS IN ESTUARINE AND TIDAL WATERS.

Frank L. Heaney.
Water Pollut Contr Fed J, Vol 32, No 6, pp 610-21, June 1960.

Descriptors: *Estuaries, Design, Construction, *Outlets, Sewers, Standards, Chlorination, *Rainfall intensity, *Overflow, *Water pollution, *Hydraulics, Maintenance.
Identifiers: *Combined sewers, *New York, N.Y., *Urban drainage.

The object of design of outfall sewers was to destroy the physical character of the sewage without objectionable odors, floating solids at shore line, scum accumulations or bottom deposits. Present day standards require, in addition, a reduction of bacterial concentration. In discussing design the author states that shore overflows from plant should be avoided and provisions should be made for emergency chlorination. In New York City experience has shown that 0.02 in/hr rainfall has resulted in discharge of approximately 30% raw sewage from combined sewer overflows. Also that from 70 years of records, one to two rainstorms of over 0.02 inch/hour occur each week during the summer. The receiving waters remain polluted for a period of one to three days after each rainfall. Author discusses location of outfalls, hydraulic considerations, and design of outlet structures. In design the author uses the charts and formulas of Rown and Palmer and shows the theoretical computations of mixing of sewage with sea water. Each area must have tests taken to assess the effectiveness of mixing. The author discusses construction and maintenance of outfall sewers and also costs of same.

094

### HYDRAULIC BEHAVIOR OF STORM WATER INLETS.

W. H. Li, J. C. Geyer, and G. S. Benton.
Sewage Ind Wastes, Vol 23, pp 34-6, 1951.

Descriptors: *Model studies, *Intakes, *Storm runoff, Hydraulics.
Identifiers: Capacity.

Formulae based on studies of model inlets are developed for calculating the capacities of various types of gutter inlet without depression. There was close agreement between the calculated and observed values.

095

### FLOW CHARACTERISTICS OF PVC SEWER PIPE.

L. C. Neale, and R. E. Price.
ASCE Proc, J Sanit Eng Div, Vol 90, No SA3, Pt 1, paper 3955,
pp 109-29, June 1964.
(through Eng Index, p 1869, 1964).

Descriptors: *Plastic pipes, *Sewers, *Sewer hydraulics, Velocity, Head loss, *Flow measurement.

Flow tests were run on 8 and 12-in. thin-wall, flexible PVC pipes designed for use as sewers. Pressure and open channel flow characteristics were investigated and analyzed. Velocity profiles were made. It is shown that temperature has significant effect that should be considered in critical or marginal designs. Head losses for solvent cemented bell and spigot joint were measured, and coefficients of 0.0011 with bell pointed downstream and 0.0068 with bell pointed upstream were determined.

096
FLOW VELOCITIES IN SMALL SEWERS.

R. D. Pomeroy.
Water Pollut Abstr, Vol 39, pp 1525-1548, 1967.
(through Water Pollut Abstr, Vol 40, No 12, p 547, Dec 1967).

Descriptors: *Velocity, *Sewers, *Sewer hydraulics.
Identifiers: *Calculations.

Methods were developed for obtaining data on velocity and discharge in sewers for use in calculating the coefficients in hydraulic equation, and these techniques were used on 95 small sewers. The data obtained, together with published studies on experimental pipes, confirm the conclusions of previous investigators that velocities in partly-filled pipes do not conform to the traditional equations. From the data obtained, equations were developed for velocities in partly-filled pipes of circular section. The experimental results also confirmed the accepted view that a velocity of 0.5-0.6 m per sec, or 1.6-2 ft per sec, is required to avoid excessive accumulations of debris. There was evidence of a retarding effect of critical-depth turbulence, but it is impracticable to avoid these effects in the smallest sewers. It was found that poor construction, including irregularities of slope, is often the cause of poor coefficients; the asbestos-cement sewers tested showed better coefficients than the vitrified-clay sewers, and the concrete sewers were poorest.

097
FLOW VELOCITY IN PARTLY FILLED PIPES.

Richard Pomeroy.
Water Sewage Works, Vol 108, p 180, May 1961.

Descriptors: *Velocity, Flow measurement, *Pipes.
Identifiers: *Calculations.

It is important, for a variety of purposes in the sanitary engineering field, to be able to calculate velocity and flow conditions in sewers running less than full. The equation which has come to be known as Manning's is most commonly used for this purpose. This equation rests upon the classical assumption that velocity can be calculated as a function of R, S, and a friction coefficient. This basic assumption is an approximation when streams of different shape of cross section are considered. This following equation has been deduced for calculating velocity of flow in a partly filled pipe of circular cross section:

$$V = k\,Q^{0.29}\,S^{0.38}\,D^{-0.13}$$

This equation conforms to available data better than the Manning equation. The value of k is related to the Hazen-Williams coefficient by the equation $k = 0.702\,m\,C^{0.71}$ in which m is approximately 1.10.

098
STORM WATER TANKS WITHOUT GRADIENTS, A METHOD OF IMPROVING THE SEWERAGE SYSTEMS OF TOWN.

F. Schimrick.
Gas Wasserfach, Vol 92, pp 156-8, 1951.

Descriptors: *Storm runoff, Design, Pumping.
Identifiers: *Storage tanks, *Urban drainage.

The author discusses the possibility of inserting storm water tanks in sewerage systems. Where the depth of the tank is somewhat less than the internal diameter of the inlet channel, no gradient is necessary. The use of such inserted tanks to reduce the load on pumping plant and sewage works is discussed with examples of their effect in various towns.

099
MEASUREMENT OF MANNING'S ROUGHNESS COEFFICIENT.

O. J. Schmidt.
Sewage Ind Wastes, Vol 31, p 995, 1959.

Descriptors: *Sewers, *Velocity, *Design, Construction, *Roughness (hydraulic).
Identifiers: *Combined sewers, *Kansas City, Mo., Urban drainage.

In connection with a master plan for trunk sewers and sewage-treatment facilities in Kansas City, Mo., a series of velocity measurements was made in a large trunk sewer carrying both sewage and storm water. The method used to measure mean velocity is described; it is considered to be as simple, accurate, and inexpensive as more conventional procedures. Variations in n in Manning's formula occur with changes in depth of flow in sewers and for certain sewer designs such variations can be important. The value of n can be changed from that used in the design of the sewer by a number of conditions brought about during construction or which can occur afterwards. Bottom deposits or other conditions which greatly alter the invert surfaces of the sewer probably caused a greater variation in n than that caused by changes in depth of flow. Some aspects on which further investigations are required, are indicated.

100
OPTIMUM DESIGN OF SEWERS.

A. A. Smith.
Civ Eng Public Works Rev, Vol 60, p 206, 1965.

Descriptors: *Sewers, *Design.
Identifiers: Capacity, Calculations.

After a brief review of the general properties of partly full circular conduits as applied to sewer design, the author shows that the effect of shape is both significant and important in the design of sewers of adequate carrying capacity. The concept of optimal sewer diameter is developed, and the relevance of criteria of self-scouring and carrying capacity is considered. A design chart is given for the solution of problems of a general nature, with some practical examples of its use.

101
SOME HYDRAULIC ASPECTS OF SEWERAGE AND SEWAGE DISPOSAL.

C. B. Townend, and G. W. Wilkinson.
Inst Civ Eng Proc, Vol 4, Pt 3, No 3, pp 662-84, Dec 1955.

Descriptors: *Sewage treatment, *Hydraulics, *Storm runoff, Discharge (water).
Identifiers: *Suspended solids.

Sequence of operations in sewers and at treatment plants; application of hydraulic principles to assure efficient transport and removal of solids; storm-water runoff, discharge formulas relating to sewers, channels and pipes; effects of sewage handling on hydraulic practice, control of velocities and levels, distribution of flow, and sedimentation procedures.

102
DEEP TUNNEL SYSTEM GETS OFF THE GROUND.

ASCE, Newsletter Sanit Eng Div, pp 7-8, May 1967.

Descriptors: *Tunnels, *Grants, *Sewage lagoons, *Flood control, Instrumentation, *Overflow, Pumping, *Sewage sludge.
Identifiers: *Combined sewers, Chicago, Ill., *Storage tanks, *New York, N.Y.

Chicago has received a $1 million grant from FWPCA to help build and demonstrate a $14,389,600 deep-tunnel system to store the rain-swollen flows in combined sewers in part of the city's northside. When the flow in the combined sewers returns to normal, the water stored in the tunnel will be pumped back into the sewer lines for treatment. Other grants awarded were to: Shelbyville, Ill. to help build a system to hold and treat combined-sewer flows in several holding and treatment lagoons and a holding tank; to New York City to help pay for the installation and evaluation of a siphon-type Ponsar regulator designed to provide better control of the flows from combined sewers into interceptor sewers; and to Columbus, Ohio to help renovate and improve the efficiency of the combined-sewer overflow holding tanks by installing new pumps which will remove sludge which now accumulates and causes odors.

103
ASCE SEWER PROJECT CONTINUES.

ASCE, Newsletter Sanit Eng Div, p 5, Jan 1967.

Descriptors: *Pumping, *Equipment, Drainage system.
Identifiers: *Sewer-within-sewer, *Combined sewers, *Urban drainage.

ASCE is continuing to study the sewer-within-a-sewer concept under a new contract. Combination grinder-pump units will be developed for both household and commercial uses. A limited number of these will go into buildings in a demonstration area and be connected to piping installed in existing combined sewers. Tests will be conducted for a six month period. At the same time, plans will be developed for a demonstration in an entire urban drainage area.

## Section IV

## SEWER SYSTEMS - COMBINED

53.A

104

### COMBINATION SEWER SEPARATED INTO SANITARY AND STORM LINES AT LOW COST.

Civ Eng, Vol 36, No 5, p 55, May 1966.
(through Eng Index, p 2738, 1966).

Descriptors: Sewers, Pipes, Tunnels.
Identifiers: *Combined sewers, Storm sewers, Minneapolis, Minn.

Sewer department of Minneapolis, Minn., has recently placed 5700 ft of corrugated steel pipe in bottom of existing combination sewer-for sewage only, to reduce load on treatment plant. Armco Smooth-Flo pipe, 42 in. in diam has asphaltic liner. Flattened to 53x22.5 in., it fits well into bottom of old 102-in.-diam tunnel. Prefabricated bands with neoprene gaskets hold sections together, and corrugated hold-down bands anchor them to tunnel wall. Concrete is then placed to prevent line from "floating" and provide smooth base for storm flow above.

105

### DATA AVAILABLE ON SEPARATING COMBINED SEWERS.

Environ Sci Technol, Vol 2, No 8, p 577, Aug 1968.

Descriptors: *Construction costs, *Overflow, *Storm runoff, Pumping.
Identifiers: *Combined sewers, *Sewer separation, *Storm sewers, *Storage tanks, *Washington, D.C.

The cost of separating the combined storm and sanitary sewers in the United States, which now serve 36 million people, is approximately $48 billion, according to a recent report prepared by the American Public Works Association for the Federal Water Pollution Control Administration. The report is a national inventory of the effects and means of correcting combined sewer overflows and separate storm and sanitary sewer discharges in the United States. A pilot project to construct two giant rubberized tanks in the Anacostia River in Washington, D.C. to store overflow during heavy rainfall is also mentioned. Each tank has a capacity of 100,000 gallons and will be anchored in the river bed. During the period of overflow, sewage will be diverted into an on-shore pump house where it will be crushed before being pumped into the tanks. The contents of the tanks will be pumped back into the sewer lines after the storm water recedes.

106

### COMPUTERS TO CONTROL COMBINED SEWERS.

Environ Sci Technol, Vol 1, No 10, p 777, Oct 1967.

Descriptors: *Computer programs, *Overflow, Storm runoff, *Automatic control, Sampling.
Identifiers: *Combined sewers, Urban drainage.

The Minneapolis-Saint Paul Sanitary District is working on a $1.7 million demonstration project to use a process control computer to control combined sewer overflows. When heavy rainfall causes the sewers to overflow, the excess is diverted into the river through gates in the sewers. The computer will be used to see that the most polluted flow goes to the treatment plant and the cleaner water to the river. The system will rely on data telemetered from 28 sampling stations to the computer at the plant. The data will include the amount of rainfall, sewer levels, and gate positions. Using simulation techniques, sewage plant operators can determine the best settings on control gates to get maximum pollution to the plant and minimum pollution to the river.

107

### WATER POLLUTION R&D GRANTS.

Environ Sci Technol, Vol 1, No 3, p 189, March 1967.

Descriptors: *Grants, *Water pollution control, Overflow, *Automatic control, *Flow control, Storm runoff.
Identifiers: *Combined sewers, *Storage tanks, *Sewer-within-sewer.

Approximately $20 million in contracts and grants were awarded in 1966 by the Federal Water Pollution Control Administration. About half the total was for studies of improved methods for dealing with overflows from combined sewers. Nine cities were awarded a total of slightly more than $8 million to help finance such projects as construction of large detention basins to hold combined sewer overflow prior to treatment, and for installation of automated sewer regulator stations designed to provide better control of combined flows. Contracts of $1.6 million were awarded to private companies to study such possibilities as building a sewer within a sewer or constructing submerged containers capable of holding combined sewer waste until it can be pumped back to the treatment plant.

108
DRAINAGE (SEWERAGE).

Inst Sanit Eng J, Vol 50, pp 177-94, 1951.

Descriptors: *Storm runoff, *Overflow, Velocity, Sewers, Flow, *Runoff, Design.
Identifiers: *Lloyd-Davies formula.

In a discussion on the C.E. Code of Practice No. 5 (1950) "Drainage (Sewerage)", subjects raised included velocity of flow in sewers, admission of trade waste waters to sewers, storm water overflows, and the Lloyd-Davies method of calculating run-off.

109
SEWER SEPARATION.

Water Wastes Eng, Vol 3, p 2, 1966.

Descriptors: Sewers, *Overflow, Design, *Water pollution.
Identifiers: *Combined sewers, *Sewer infiltration.

Engineers and Superintendents of Sewer systems representing a cross-section of the country were asked several questions regarding their systems. These questions included miles of different-types of sewers, if infiltration was a problem, number and types of regulators and diversions used, design of combined system and if any bottlenecks, and an estimate of percentage and amount of pollution bypassed each year. Answers indicated that infiltration was a problem in several cities, but the sewage lost from bypassing or overflows was not a significant pollution problem.

110
SEWER WITHIN A SEWER.

Water Works Wastes Eng, Vol 1, pp 36-37, 101, Feb 1964.

Descriptors: *Sewers, *Plastic pipes, *Construction, Construction costs.
Identifiers: *Combined sewers, *Ottawa, Canada.

Ottawa, Canada constructed small gravity sewers inside 2 existing large-diameter combined outfall sewers to convey intercepted sanitary flow to a new main interceptor tunnel. The inner sewer slopes in the opposite direction from the outer sewer, which is accomplished by starting the high end of the inner sewer at the top of the large sewer and spiraling it down the outer sewer wall. In one location because of corrosive wastes the inner sewer consists of 1440 ft. of 15 in. dia. PVC plastic pipe. In the other location the inner sewer is 1303 ft. of 12 in. CI pipe. The 15 in. sewer cost $20.41 to $24.41 per ft. in place. The sewer within a sewer technique permitted main interceptor modifications that saved an estimated $1,200,000. When completed, the main interceptor system will consist of 38,300 ft. of 72 in. to 96 in. dia. tunnel.

111
[FACTS ABOUT COMBINED SEWER SYSTEMS].

Water Wastes Eng, Vol 4, No. 11, p 78, Nov 1967.

Identifiers: *Combined sewers.

Facts about combined sewer systems are being collected by the American Public Works Association. A $250,000 grant from the Federal Water Pollution Control Administration has been awarded to the Association, whose representatives will conduct on-site interviews with water officials of about 900 communities with combined sewer systems. All cities with populations over 25,000 will be included in the survey and checks will also be made on 30 percent of smaller communities having this type of system.

112
DRAINAGE (SEWERAGE).

C E Code of Practice No 5, Inst Munic Eng, London, 1950.

Descriptors: *Design, *Sewers, Manholes, *Storm runoff, *Overflow, Siphons, Pumping, *Runoff.

In a Code of Practice intended to indicate what is considered to be good practice in the design and construction of sewerage systems under average conditions, recommendations are made concerning choice of sewerage system, layout, size, shape, depth and gradient of sewers, manholes, storm-water overflows, siphons, pumping stations, pumping mains, tidal outfalls, and other works. Information is given on legislation concerning discharge of trade waste waters to sewers and on the effect of some types of trade waste waters on sewerage systems and on natural waters. In an appendix, a suggested method for calculating run-off is described.

113
SEPARATING STORM AND SANITARY SEWERS IN URBAN RENEWAL.

32nd Report by the Committee on Govt Operations, US House of Representatives, House Rept 1648, US Govt Printing Off, Washington, DC, June 23, 1966. 20 p, 2 tab.

Descriptors: *Water pollution, Grants.
Identifiers: *Storm sewers, *Sewer separation, *Combined sewers, Urban drainage.

The need for separating storm and sanitary sewers is discussed, with emphasis on separating such sewers in areas being developed or redeveloped under federal aid. The 1962 Public Health Service Table on number and size of communities served by combined sewer systems is given. A 1964 Public Health Service appraisal of combined sewers is outlined. Demonstration grants to develop measures to control pollution from combined sewers are described. Problems and controversy concerning separation of sewers in the University-Euclid urban renewal project in Cleveland are discussed and other sewer programs are outlined.

114
DISPOSAL OF MUNICIPAL SEWAGE (WATER POLLUTION CONTROL AND ABATEMENT).

Union Calendar No 90, 89th Cong, 1st Sess, Rep No 204, 1965. U S House of Representatives. 40 pp.
(through Water Pollut Abstr, Vol 39, No. 10, p 340, Oct 1966).

Descriptors: *Water pollution, *Storm runoff, *Overflow.
Identifiers: *Combined sewers.

This is the 12th report of the U.S. Committee on Government Operations and is based on a study made by its Natural Resources and Power Subcommittee to examine whether Government agencies are coping effectively with water pollution problems and to determine possible improvements in techniques for preventing and controlling pollution of rivers and other water resources. The present position and problems of sewage disposal are reviewed in relation to water pollution, including the problems caused by combined sewerage systems and storm-sewage overflows, and recommendations are made for future action by Government departments; comprehensive planning and co-ordination of sewage-treatment facilities for municipal areas; and development of new methods of sewage treatment.

115
INTERCEPTORS HAVE UNUSUAL DESIGN FEATURES.

W. M. Bailey.
Water Wastes Eng, Vol 4, No 1, pp 55-7, Jan 1967.
(through Eng Index, p 2473, 1967).

Descriptors: *Design, Sewers, Storm runoff, Sewage treatment.
Identifiers: *Interceptor sewers, *Omaha, Nebr.

Waste collection and treatment installation in Missouri River basin in Omaha, Nebr. is described. Project includes 64,700 ft of collecting sewers and plant that gives primary treatment to wastes before discharging them into river. Bi-directional sewer operates during low flow periods as gravity sewer flowing in one direction. During time of storm flow, it becomes force main that flows in two directions. Another feature is segregated treatment plant that permits low strength and high strength wastes to be treated separately or mixed in any desirable proportion.

116

## STORM-WATER OVERFLOWS FROM COMBINED SEWERS.

H. H. Benjes, P. D. Haney, O. J. Schmidt, et al.
Water Pollut Contr Fed J, Vol 33, p 12, 1961.

Descriptors: *Storm runoff, *Overflow, *Rainfall-runoff relationships.
Identifiers: *Combined sewers, Kansas City, Mo., *Interceptor sewers.

Advocate using peak dry-weather flow rather than average dwf in determining a ratio for interceptor sewers. This helps decrease the percent difference in peak to average dwf found because size of community. Agree with other investigators that from 0.03 to 0.04 in./hr is needed to wet down area before run-off. Each 0.01 in./hr will produce run-off equal to dwf. In Kansas City it was found that measurable rainfall occurred about 5 percent of the time. Of this 3.7 percent of the time run-off could occur. With a peak dwf of 1.5 x ave. dwf and a interceptor capacity of 1.5 x ave. dwf it was found overflow would occur 3.72 percent time = to peak dwf. If interceptor was increased to 3.5 x ave. dwf, overflow would still occur 3.22 percent of time and 6.5 x ave. dwf 2.3 percent of time. Authors conclude that the practical maximum effective capacity of interceptor cannot be much larger than the peak dwf. Also recommend more work be done in characteristics of storm-water run-off.

117

## PRINCIPLES FOR CALCULATING FLOWS IN SEPARATE AND COMBINED SEWERS.

Waclaw Blaszczyk.
Gaz Woda Tech Sanit, Vol 26, No 1, p 24, 1952.

Descriptors: *Rainfall intensity, *Design, *Sewers, *Flow measurement.
Identifiers: *Combined sewers, Warsaw, Poland.

Following a review of the theory of calculating combined sewer flows by means of several expressions, the author presents time-intensity plots proposed by various authorities for Warsaw, in which intensities for a rainfall of 1/2 min. vary from 25 to 202 l. per second per hectar; for t = 1 min., i varies from 16 to 124; for t = 1 min., i varies from 16 to 124; for t = 2 min., i varies from 12 to 70; and for t = 3 min., i varies from 9 to 58. In many projects, the results are based upon the experience of the designer as indicated by the data cited above. Accordingly, the author proposes that it is necessary to come to some agreement as to the coefficient of probability to be used for economical sewer design, and that it should not be necessary to depend wholly upon the judgment of the designer. Of course, the establishment of suitable norms must be based upon thorough and complete calculations and review of existing data. No one, according to the author, has dependable results, as practically none of the designers have had the opportunity of confirming their calculations in practice, because in many cases the system has not been completed as designed, the drainage area has not been fully settled, or the rains designed for have not occurred.

118

INTERCEPTOR SEWERS.

E. E. Bloss.

Paper presented at Amer Soc of Civ Eng Meeting, Oct 18-22, 1965,
Kansas City, Missouri.

Descriptors: Design, Pumping, Treatment, *Flow measurement, Hydrographs, Overflow, Storm runoff, *Water pollution control, Hydraulics, Construction costs.
Identifiers: *Interceptor sewers, *Capacity, St. Louis, Mo., Combined sewers, Sewer infiltration.

Subject matter discussed in this paper on interceptor sewers applies specifically to the design of the interceptor sewers of the Metropolitan St. Louis Sewer District Pollution Abatement Project. The paper includes as background information, a brief description of the District, as well as a brief description of the overall plan of the proposed interception, pumping and treatment facilities. The methods used in gaging present flows are also discussed and a number of measured sewer hydrographs are reproduced. Detailed investigation of the spill of mixed sewage and rainfall with interceptors of several different capacities is discussed in considerable detail leading to the finding that adequate abatement of pollution can be achieved with interceptors having a capacity equal to the peak rate of sewage flow. In this investigation sewage flow was considered to consist of domestic and industrial waste flow only; it did not include ground water infiltration. However, to completely avoid spill during dry weather, it was further concluded that interceptors, in final design should have a capacity equal to the peak flow of sanitary sewage plus the peak rate of ground water infiltration. Detailed computations of sewage spill were made under conditions of present and assumed ultimate watershed development for interceptors on two of the largest sewers of the District as finally designed. Two typical interceptor structures are discussed and illustrated. Storm water flows for several assumed runoff rates and the effects of such flows on the hydraulics of the trunk interceptor sewer are discussed. Finally, in order to illustrate the disporportionate effect on cost when compared to the small improvement in pollution abatement accomplished by increasing interceptor capacities, the trunk sewer was resized to accommodate 1.25

times peak dry weather flow. A cost estimate of the trunk to carry the larger flow was prepared and compared with the estimated cost of the trunk as designed. The reduction in degree of pollution abatement which would have been achieved by the slightly larger interceptor was also computed and shown to be inconsequential. The economic inadvisability of increasing interceptor capacity beyond one times peak dry weather flow for the St. Louis sewer system was demonstrated.

119

### SURVEY OF NAJAFGARH DRAIN DOWNSTREAM OF INDUSTRIAL AREA.

K. R. Bulusu, and V. P. Sharma.
Environ Health, India, Vol 8, pp 103-111, 1966. 3 tab.
(through Water Pollut Abstr, Vol 40, No 3, p 139, March 1967).

Descriptors: *Storm runoff, Discharge (water), *Dissolved oxygen, *Biochemical oxygen demand, Water Quality, Standards, *Rainfall intensity, *Water pollution.
Identifiers: *Suspended solids, *Combined sewers, Jumna River, India.

During the period March-July 1962, the Najafgarh drain, which carries a mixture of industrial waste water and sullage besides storm water, and the stretch of the Jumna river into which it discharges, were surveyed 11 times from 12 stations. Graphs and tables are given showing quantitative data on total and suspended solids, dissolved and absorbed oxygen, BOD, chlorides and sulphates. The quality of the river water at a station near the point of discharge was judged to be satisfactory in relation to the requirements of the Indian Standards Institution and it is concluded that, during the summer, the quality of the water is suitable for use at a downstream water works and by riparian owners, but that heavy rains will cause excess pollution as a result of bottom scouring.

120

## THE BACTERIOLOGICAL EFFECT OF COMBINED SEWER OVERFLOWS ON THE DETROIT RIVER.

R. J. Burm.
Water Pollut Contr Fed J, Vol 39, No 3, p 410, March 1967.

Descriptors: *Overflow, Discharge (water), *Coliforms, *Water quality, *Rainfall intensity.
Identifiers: *Combined sewers, Detroit, Mich.

A study of water quality at various points in the Detroit River before and after rainfalls causing overflows of combined sewers showed that, in at least this case, effects of these overflows persist for several days after discharge has ceased, with duration of effects increasing with increase in the intensity of the storm. Bacterial densities may increase a thousandfold after moderate rains at sampling points, within several miles downstream from combined sewer outfalls. Farther downstream, increases in bacterial densities are less, but occur over greater portions of the stream width. Fecal coliforms and fecal streptococci follow patterns similar to those of total coliforms.

121

## THE PROBLEM OF SEPARATION IN PLANNING SEWER SYSTEMS.

T. R. Camp.
Water Pollut Contr Fed J, Vol 38, No 12, pp 1959-1962, Dec 1966.

Descriptors: *Overflow, *Sewers, *Water pollution, Construction costs.
Identifiers: *Sewer separation, *Combined sewers, *Storm sewers, Suspended solids.

Sewers originally were constructed to drain cellars and land, and later were permitted to carry sanitary wastes. Many older cities in the United States have combined type of sewer system and now face the need for separate systems for sanitary wastewater and stormwater. The costs are estimated to be $10,000-$20,000/acre ($25,000-$50,000/ha), not including the cost of the possible repairs to storm sewers. Although only three percent of the annual wastewater production is discharged by combined sewer overflows, greater amounts of bacteria and suspended solids are dislodged by high flows after storms. Other methods proposed to alleviate overflow effects are not so effective as separation.

122

## OVERFLOWS OF SANITARY SEWAGE FROM COMBINED SEWERAGE SYSTEMS.

Thomas R. Camp.
Sewage Ind Wastes, Vol 31, No 4, April 1959.

Descriptors: *Overflow, *Storm runoff, Rainfall intensity.
Identifiers: *Capacity, *Interceptor sewers, *Combined sewers.

The author notes that it has been shown that the average dry weather flow of sanitary sewage is approximately equal to the runoff from a rainstorm having an intensity of about 0.01 in/hr. For interceptors having a capacity of 2 x dry weather flow, more than 90 percent of sanitary sewage is discharged in the overflows with a rainfall intensity of 0.2 in/hr or more. With interceptors having capacity of 5 x dry weather flow, about 76 percent of sanitary sewage is lost during rainstorms having an intensity of 0.2 in/hr and about 90 percent is lost during rainstorms having an intensity of 0.5 in/hr. Frequency of overflows indicate that one may occur every 5 to 6 days during summer with interceptors designed for 1.5 to 3 x average dry weather flow. Chart of frequency of overflows in days/mo vs. capacity of interceptors in terms of average dry weather flow and variable time of concentration.

123

## IMPROVEMENTS IN SYSTEMS OF 'COMBINED' SEWERAGE.

R. C. Carter.
Inst Sanit Eng J, Vol 49, pp 105-27, 1950.

Descriptors: Water pollution control, *Storm runoff, *Overflow, *Sedimentation, Sewage effluent, Sewage sludge.
Identifiers: *Combined sewers, *Storage tanks, Interceptor sewers, *Capacity.

The author discusses the possibility of reducing pollution caused by discharge of storm water from combined sewers. It would not be economical to build sewers large enough to carry the max. flow to be expected, for example once each year, but storm overflows which discharge to a stream when the flow exceeds 6 x dry-weather flow cause considerable pollution. Storm tanks are a more satisfactory method of dealing with storm water, as sedimentation can take place and the effluent when the tank overflows is of a less polluting nature. It is suggested that an existing combined sewerage system could be expanded by constructing large storm water balancing tanks at various points on the main intercepting sewer. Storm water could be stored in these tanks and discharged to the sewers as capacity is available. A method for calculating the required capacity of the storm water balancing tanks is shown in a table. In discussion, E. V. Bevan, G. L. Ackers, and G. B. Towsend, all stated that the system proposed would be the removal of the sludge which would accumulate in the balancing tanks and might give rise to septic conditions (Surv, Vol 108, pp 743-5 (1949)).

124

## IMPROVEMENTS IN SYSTEMS OF COMBINED SEWERAGE.

R. C. Carter.
Surv, Vol 108, No 3019, p 743, Dec 16, 1949.

Descriptors: *Storm runoff, *Overflow, *Weirs, Design, Pumping, Treatment.
Identifiers: *Storage tanks, Suspended solids.

The author states that storm overflow weirs are an illogical weakness in design and should be eliminated wherever possible. Overflow from storm tanks is much to be preferred to storm sewer overflows as the overflow from the tanks has been rid of virtually all settleable suspended matter. Author derives a procedure utilizing storm balancing tanks which take excess storm water from upper laterals and later return the flow by pumping. Thus the peaks are removed and all storm water ultimately gets treatment, either total or at least storm tank.

125

## ESTIMATION OF THE FLOOD FLOW AND DISCHARGE COEFFICIENT IN SEWERAGE SYSTEMS.

T. Dimchev.
Trud Nauch Inst Vodosnab Kanaliz Sanit Tech, Sofia, Vol 1, pp 53-78, 1964.
(through Water Pollut Abstr, Vol 39, No 7, p 232, July 1966).

Descriptors: *Sewage treatment, *Discharge (water), Rainfall itensity.
Identifiers: *Calculations, *Urban drainage.

Hydrological observations made in 1958-61 in an area drained by part of the Sofia sewerage system are reported and analysed mathematically with reference to the dry-weather flow and to peak discharges and discharge coefficients in the main sewer, including the effects of surface detention of rain water (which varies with the intensity of rainfall), duration of rainfall (which is inversely related to the peak flow), and the free volume in the sewer.

126
FOCUS ON RESEARCH. WATER POLLUTION RESEARCH AND THE MUNICIPAL ENGINEER.

A. L. Downing.
Inst Munic Eng J, Vol 92, pp 185-188, 1965.
(through Water Pollut Abstr, Vol 40, No 2, p 89, Feb 1967).

Descriptors: *Water pollution, Automatic control, Instrumentation, *Storm runoff.
Identifiers: *Combined sewers.

The work and publications of the Water Pollution Research Laboratory relating to problems encountered by municipal engineers are outlined. Brief details are given of recent investigations on the effects of pollution on fish; the oxygen balance in rivers and estuaries; the dispersion of sewage from coastal outfalls; the fundamentals of established sewage-treatment processes, and the development of instruments for their automatic control; the operation of extended-aeration plants; tertiary treatment for polishing sewage-works effluents; the inhibition of sludge digestion by detergents and certain industrial effluents discharged to sewers; and the composition and flow of storm sewage in combined systems.

127
POLLUTION CONTROL FOR STORM WATERS AND COMBINED SEWER OVERFLOWS.

D. D. Dunbar, and J. G. F. Henry.
Water Pollut Contr, Vol 105, No 11, p 41, 45, 47, 52-3, Nov 1967.
(through Eng Index, p 164, April 1968).

Descriptors: *Water pollution control, *Storm runoff, *Overflow, Design.
Identifiers: *Combined sewers, Capacity, *Interceptor sewers, *Storage tanks, Canada, United States.

Methods and practices in United States and Canada to improve combined sewer efficiency are discussed. Problem of how large intercepting sewer capacities should be in relation to average dry weather flow in combined sewer system is dealt with, as well as the design of storm holding tanks.

128
TROUBLE-FREE COMBINED SEWERAGE SYSTEMS.

L. B. Escritt.
Surv, Vol 113, p 603, July 17, 1954.

Descriptors: Sewers, Pipes, *Storm runoff, *Velocity, Design.
Identifiers: *Combined sewers, *Capacity.

The author presents both the valid and "fallacious" arguments for the preference of separate over combined sewerage systems. He repudiates the most commonly given reasons for not using combined system; that is, that the large size pipes necessary for the storm flow will be silted during dry weather flow and if the gradient is increased to bring the dry weather flow to self-cleansing standards, excessive depth will result. He points out "that, while increase of diameter above that required for the flow does usually reduce velocity, this reduction is very small indeed, so that in the majority of instances a combined sewer has a satisfactory self-cleansing gradient if it is laid to the same gradient as would be adopted for the soil sewer if the system were to be made separate." An example is given.

129
THE ENGINEERING PROBLEM OF BALANCING RATE OF FLOW AND STRENGTH OF SEWAGE.

L. B. Escritt.
Surv, Vol 104, p 221, 1945.

Descriptors: Design, *Weirs, *Sewage treatment, *Storm runoff.
Identifiers: *Storage tanks.

The design of weirs for separating storm water to be given partial treatment is discussed. Discussed design of storm water tanks having a 6-hour dry weather flow capacity.

130
AKRON MONITORS COMBINED SEWER OVERFLOWS.

E. Gates.
Public Works, Vol 98, No 1, pp 90-1, Jan 1967.
(through Eng Index, p 2472, 1967).

Descriptors: *Overflow, Instrumentation, Pumping, *Equipment.
Identifiers: *Combined sewers, *Interceptor sewers, Akron, Ohio.

Monitor and control units for combined sewer system are described. Basic equipment consists of Tel-Eye liquid contact sensors at pump stations and connections between storms and interceptors, Telstep telemetry units signaling over leased telegraph channel lines, and master panel at sewer maintenance headquarters.

131
STORM WATER AND COMBINED SEWAGE OVERFLOWS.

S. A. Greeley, and P. E. Langdon.
ASCE Proc, J Sanit Eng Div, Vol 87, No SA1, 1961.

Descriptors: *Storm runoff, *Overflow, *Water pollution, Storms, Sewers, *Biochemical oxygen demand, Sewage Treatment, *Chlorination, *Pathogenic bacteria.
Identifiers: *Combined sewers.

Most of the larger and older cities in the U.S.A. are served by combined sewerage systems resulting in pollution of waterways through overflows during storms. Such pollution could be removed by complete separation of storm water and sanitary sewage by the construction of a new system of sanitary sewers, but this would be expensive and inconvenient and is therefore of limited application. The interception and treatment of the dry weather flow and the first flushings of storm water will reduce the volume of sewage discharged through overflows to about 3 percent of the total sewage flow, and with complete treatment of the intercepted flow about 90 percent of the BOD can be removed. Treatment of intermittent discharges from overflows by retention and chlorination to remove floating solids and bacterial contamination can also improve conditions in receiving streams at reasonable cost.

132

### INTERCEPTING SEWERS AND STORM STANDBY TANKS AT COLUMBUS, OHIO.

J. H. Gregory, R. H. Simpson, O. Bonney, et al.
ASCE Proc, Vol 59, p 8, Oct 1933.

Descriptors: Design, Construction, *Overflow, *Rainfall intensity, *Water pollution.
Identifiers: *Storage tanks, *Interceptor sewers, Columbus, Ohio.

Design, construction, and operation of sewerage system extension which is to provide for estimated population of 643,000 in 1960; overflow of sewage to rivers and streams; relieving unsanitary conditions in Scioto River and in Alum Creek; intensity, duration and frequency rainfall curves; function of storm standby tanks; cost data.

133

### COMBINED SYSTEM OF SEWERAGE WITH LIMITED RAW WATER INLET.

Walo Von Greyerz.
Trans Int Conf Sanit Eng, London, pp 170-80, 1924.

Descriptors: Pipes, Sewers, *Storm runoff, *Rainfall intensity, *Runoff forecasting, Drainage systems, *Intakes, Construction costs.
Identifiers: *Combined sewers, Capacity, *Cellar flooding.

The combined system of sewerage while having many advantages is at times criticized because of excessive cost on account of the large pipe sizes required to accomodate the maximum run-off from severe storms which are of short duration. Lack of attention to this condition results in flooded cellars. These objections may be overcome to a large extent by designing the inlets for a limited capacity which the sewer can accomodate and utilizing the storage capacity of the streets to hold the surplus run-off. The streets are thus temporarily flooded to a depth of an inch or two. When the rate of precipitation slackens the stored water quickly drains off through the inlets. This limitation of rain water inlets unites both the simplicity and efficiency of the combined system and two of the advantages of the separate system, namely freedom from risk of cellar flooding and reduced construction cost. Data are presented for the town of Falkenburg for which such a system was designed, taking into account the various street grades and resultant gutter capacities. The methods of computing rates of run-off, inlet sizes, etc. are given in some detail. The discussion disclosed that this method was also in use in India and Panama.

134

RATIONAL DETERMINATION OF STORM OVERFLOWS FROM INTERCEPTING SEWERS.

S. G. Hess, and F. G. Manning.
Sewage Ind Wastes, Vol 22, pp 145-53, 1950.

Descriptors: Design, *Overflow, Storms, Runoff.
Identifiers: *Interceptor sewers, *Combined sewers.

A method is described for designing intercepters for use with combined sewer systems based on dry weather flow and run-off of a selected storm.

135

STORM WATER OVERFLOW IN EXISTING COMBINED SEWERS.

H. Hoffman.
Bauamt Gemeindebau, Vol 31, p 269, 1958.

Descriptors: Design, Sewers, *Storm runoff, *Overflow, Sewage treatment, *Oxidation lagoons, *Hydraulic design.
Identifiers: *Combined sewers.

The author describes the design of a sewer section by which storm water up to a given dilution is retained and can be discharged to an oxidation pit before reaching the stream. Hydraulic requirements are discussed and a sketch plan is given.

136

WATER SUPPLIES AND SEWAGE DISPOSAL IN BERLIN.

K. Hühnerberg.
Gas Wasserfach, Vol 104, pp 1203-1213, 1963.
(through Water Pollut Abstr, Vol 38, No 1, p 2, Jan 1965).

Descriptors: *Sewage treatment, *Storm runoff, *Overflow, Sedimentation.
Identifiers: *Combined sewers, Capacity, Berlin, Germany.

A detailed illustrated description is given of the sources and treatment of water supply and of sewage disposal in the area of West Berlin from the Elbe-Saale to the Oder and Néisse. Increased demands due to industrial development have necessitated extensions and reconstructions of existing water works and construction of new water works and sewage-treatment plants. The performance of the various water works is tabulated. Finally, the author discusses the advantages of combined over separate sewerage systems and the design and dimensions of sedimentation tanks and storm-water overflows.

137
EQUIPMENT, METHODS AND RESULTS FROM WASHINGTON, D C, COMBINED SEWER OVERFLOW STUDIES.

C. Frank Johnson.
Water Pollut Contr Fed J, Vol 33, July 1961.

Descriptors: *Overflow, Design, Sewage treatment.
Identifiers: *Urban drainage, *Combined sewers, Washington, D.C.

The study provided city officials with engineering estimates of the actual overflows of sanitary sewage, both present and future, which were of great help in developing and promoting the program of sewerage improvements.

138
ADVANTAGES AND PROBLEMS OF COMBINED SEWERAGE SYSTEMS.

P. Kisser.
Gesundh Ing, Vol 81, p 245, 1960.

Descriptors: Sewers, Design, *Storm runoff, *Overflow, Sedimentation.
Identifiers: *Combined sewers, *Capacity, *Storage tanks.

The author discusses the advantages of combined over separate sewerage systems and the design and dimensions of storm-water overflows and sedimentation tanks.

139

## SEPARATE SYSTEMS-COMBINED SYSTEMS?

E. Kuntze.
Abwass Tech, Vol 17, No 1, pp 8-10, 1966.
(through Water Pollut Abstr, Vol 41, No 2, p 66, Feb 1968).

Descriptors: *Sewers, Sewage treatment, Water pollution, *Storm runoff, *Overflow, Pumping, Groundwater, Velocity.
Identifiers: *Combined sewers.

The author discusses, on the basis of experience, the advantages, disadvantages and economics of existing sewerage systems and compares the efficiency of the separate system with the combined system. Taking into account the requirements for sewage treatment and prevention of pollution of streams, detailed information is given on how risks of pollution by storm-sewage overflows and rain-water pumps can be avoided. Taking into consideration the availability of existing sewerage systems, receiving waters, and local conditions, the author suggests that it must be decided individually whether the separate or the combined system is preferable. Where a new sewerage system is to be installed and good ground-water conditions prevail, the combined system was found to be more economical and adaptable; however, where the velocity of flow is low and a higher water level is required, the separate system is preferable especially when mineral substances can be washed away by the storm-sewage system.

140

## THE TRUNK SEWER SYSTEM AND THE SEWAGE-TREATMENT PLANT OF THE TOWN OF UTRECHT. HISTORY AND TECHNICAL LAY-OUT.

M. Lugt.
Ing Grav, Vol 77, G.1-G.7 and G.9-G.20, 1965.
(through Water Pollut Abstr, Vol 38, No 7, p 229, July 1965).

Descriptors: *Sewage treatment.
Identifiers: *Combined sewers, Utrecht, Netherlands.

After outlining the events that led to the construction of sewage-treatment facilities at Utrecht, the Netherlands, the author gives an illustrated description of the combined sewerage system and new treatment plant. The plant, which is designed to serve a population of 400,000, provides treatment by high-rate biological filtration with recirculation of effluent. Sludge is digested in two stages, dried on beds and used as fertilizer; sludge gas is used in dual-fuel engines to generate electricity.

141
PROGRESS REPORT-ASCE COMBINED SEWER SEPARATION PROJECT.

M. B. McPherson.
Civ Eng, Vol 37, No 12, pp 61-2, Dec 1967.
(through Eng Index, p 164, April 1968).

Descriptors: Pumping, *Design, *Equipment, Velocity, *Head loss, *Pressure conduits, Pipes, Sewage treatment.
Identifiers: *Combined sewers, *Sewer separation, Residential sewers.

General concept for separation of combined sewerage systems involves pumping comminuted or ground sewage from individual buildings through pressure tubing to new and separate sanitary sewage pressure conduits to treatment works. Investigation of existing comminutor installation is discussed. Research to establish design criteria for minimum transport velocities of sewage in pressure pipes; research on head losses for pipe within combined sewer; field investigations into feasibility of inserting pressure tubing in existing building sewers; letting of contracts to develop household grinder-storage-pump units and hanger system for suspending pressure conduit in combined sewers are presented.

142
ASCE COMBINED SEWER SEPARATION PROJECT PROGRESS.

M. B. McPherson.
Conf Preprint 548, presented at Amer Soc Civ Eng Nat Meeting on Water Resources Eng, New York, NY, Oct 16-20, 1967. 21 pp refs.

Descriptors: Overflow, Velocity, Computer programs.
Identifiers: *Sewer-within-sewer, *Combined sewers, *Sewer separation.

Over 100 persons, including staff members of various subcontracting organizations, are actively studying the "sewer-within-sewer" concept of combined sewer separation, of pumping ground sewage from individual buildings through relatively small pressure tubing. Experimental and field data are being collected on grinding and pumping devices, installation of tubing in shallow trenches in place of non-walk-through sewers, types of tubing and connections, effect of installation on sewer surcharge capacity, transport velocity, and computer simulation, among others. About two dozen reports are expected, including some on concomitant solid waste disposal, and home-owner acceptability.

143

### WEST HARTLEPOOL SEWERAGE SCHEME WILL CLEAN BEACHES.

J. S. Miles.
Munic Eng, Vol 141, p 47, 1964.
(through Water Pollut Abstr, Vol. 38, No. 8, p 272, Aug 1965).

Descriptors: *Storm runoff, *Overflow, *Outlets, Pumping, Water pollution control, *Recreation facilities.
Identifiers: *Combined sewers, Great Britain.

Work is in progress on a major sewerage scheme for West Hartlepool C.B.C., aimed at cleaning up 3 miles of beach and inshore waters between Newburn Bridge and the mouth of the river Tees. West Hartlepool is sewered on the combined system, most of the borough being drained through 3 outfalls. The scheme will be carried out in 2 main stages, providing first for the reconstruction of the existing outfalls as storm-water overflows and the construction of 3 pumping stations together with means of mascerating the sewage, and second, if conditions in Hartlepool bay are found to be suitable, for the laying of a long outfall buried in the sea bed.

144

### [DESIGN OF RAIN OVERFALLS IN DRAINAGE NETWORKS AND SEWAGE TREATMENT PLANTS.] Zur Frage der Bemessung von Regenueberfaellen bei Entwaesserungrnetzen und Klaeranlagen.

G. Mueller-Neuhaus.
Gesundh Ing, Vol 71, pp 9-10, 149-52, May 1950.

Descriptors: Drainage systems, *Storm runoff, *Water pollution, Design, *Overflow, Sewage treatment.
Identifiers: *Urban drainage.

Design of rain overfalls in drainage networks and sewage treatment plants; considerable difference between run-off and sewage flow off with varying density of population; average pollution of city waste water; degree of dilution required for sewage, diagrams, charts.

145

## EFFECT OF VARIOUS STORM-WATER PROTECTIVE MEASURES ON THE SEWAGE SYSTEM.

W. Munz.
Schweiz Z Hydrol, Vol 28, pp 184-237, 1966.
(through Water Pollut Abstr, Vol 41, No 5, p 214, May 1968).

Descriptors: *Storm runoff, *Sewage treatment, *Overflow, Biochemical oxygen demand, *Planning, Sewage effluent, Water pollution control, *Rainfall-runoff relationships.
Identifiers: *Combined sewers, *Storage tanks, *Calculations, Suspended solids.

The author describes the mathematical analysis of the effect and efficiency of various decisions which might be necessary in planning treatment for the flow from a combined sewerage system, and calculates the annual amounts of settleable solids and BOD which may be removed by various settings of storm-sewage overflows and volumes of storage tanks. Storage tanks are useful when high degrees of treatment are required. The relation between rainfall and run-off from various types of terrain, the duration of run-off, and the quality of sewage in a combined system are considered, and the relation between the required quality of final effluent and the volume of the aeration tanks in an activated-sludge plant are estimated.

146

## FEASIBILITY OF COMBINED SEWER SYSTEMS.

C. L. Palmer.
Water Pollut Contr Fed J, Vol 35, 162, Feb 1963.

Descriptors: *Design, Storm runoff, Rainfall intensity, Water quality, Discharge (water).
Identifiers: *Combined sewers, *Storage tanks, *Capacity.

Any properly designed and constructed combined sewer, without making use of the storm water storage, will produce results in the range of 98 percent efficiency and any expenditure of public funds to improve its operation should not be made until necessity can be clearly shown. The adoption of the plan of designing storm water storage into combined systems to the extent possible or desirable, will increase the efficiency of any combined system correspondingly. Generally speaking, the designing of storm water storage into a combined system increases the cost very little. Adding this feature to an existing system would cost more but would still not be a major expenditure. Separate systems will discharge to the receiving waters with every storm exceeding 0.03 in/hr or about 89 times each year for the area studied, and the quality of the storm-water discharge will be objectionable and closely comparable to that from a combined system. Combined systems, designed to make use of "volumetric storage" for the containment of storm water, and based on the volume of a 1-year storm, would discharge to the receiving water only from 3 to 5 times each year, with a duration of about 0.4 percent of total time, which corresponds to an efficiency of about 99.6 percent.

147
COMBINED SEWER OVERFLOWS.
Great Lakes - Ill. River Basin Project, PHS, HEW, Chicago, Ill.
Carlysle Pemberton.
Paper presented at the Water Resources Eng Conf, ASCE, Milwaukee, Wis, May 13-17, 1963. 20 p, 2 fig. 14 ref.

Descriptors: *Overflow, Flow measurement, *Water pollution, *Biochemical oxygen demand, Storm runoff.
Identifiers: *Combined sewers, *Suspended solids, Chicago, Ill.

A study was made of flow rates and composition of overflows from a large combined sewer serving a residential area of 8.6 square miles with a population of 144,300. Overflows occurred during 1.7 percent of the time, in a 14-month period when rainfall was about 75 percent of normal. Gross bacterial pollution was discharged during overflows, limiting the use of the receiving waters from a public health standpoint. Suspended solids concentration in the overflow was greater on the average than that of dry weather flow, with considerable variation associated with rainfall intensity and time since the last storm. The 5-day BOD concentration in the overflow averaged about one-half that of dry weather flow, and was found to decrease with time after overflow started. The total BOD load discharged during overflows was 2.5 times the dry weather BOD load for the same number of hours. By extension of the observed data, it is estimated that the BOD load resulting from combined sewer overflows accounts for about 19 percent of the total BOD load in the canal system serving the Chicago area.

148

### FREQUENCY OF FLOW OVER STORM-WATER OVERFLOWS AND STORAGE POSSIBILITIES IN THE SEWERAGE SYSTEM.

S. Pfeiff.
Gas Wasserfach, Vol 103, p 84, 1962.

Descriptors: *Storm runoff, *Overflow.
Identifiers: Capacity.

From investigations of the frequency of action of storm-water overflows, the factors which must be taken into account in calculations are discussed and the possibility and importance of increasing the storage capacity of the sewerage system are considered.

149

### NEW PRINCIPLES FOR THE ARRANGEMENT OF STORM WATER OVERFLOWS.

S. Pfeiff.
Gesundh Ing, Vol 79, pp 208-13, 1958.

Descriptors: Storm runoff, *Overflow, Design, Construction.
Identifiers: *Combined sewers, *Calculations.

Variations in the requirements for storm water overflows in combined sewerage systems are discussed and the generally accepted process of calculation is described. The basic requirements of overflows and the extent to which these are met by modern methods of construction are considered.

150

### NEW PROCESS FOR SIMPLE CALCULATION OF DILUTION VALUES FOR STORM WATER OVERFLOWS IN COMBINED SEWERAGE SYSTEMS.

S. Pfeiff.
Gesundh Ing, Vol 77, pp74-7, 1956.

Descriptors: *Storm runoff, *Overflow.
Identifiers: *Calculation, *Dilution, *Combined sewers.

The author discusses the uncertainties involved in the usual processes for the calculation of storm water overflows with the help of fixed dilution figures. He recommends the use of local frequency curves based on rainfall statistics, from which in each case a value can be determined for the rainfall limit at which the overflow comes into action. He shows how the overflow and the dilution can be reliably calculated from this limit figure.

151

### UNDERFLOW SEWERS FOR CHICAGO.

Milton Pikarsky, and C. J. Keifer.
Civ Eng, Vol 37, No 5, pp 62-65, May 1967.

Descriptors: *Tunnels, *Tunnel construction, *Discharge (water), *Construction costs, *Computer programs, *Overflow, Water pollution. Identifiers: *Combined sewers, *Chicago, Ill., *Storage tanks, "Mole" tunneling.

Chicago plans to use a tunneling mole to construct a large tunnel under the rivers and canals into which all of its combined sewers would discharge. The cost of building the tunnel, referred to as the "underflow mainstream", using this method is $2 million less than that for the conventional open-cut method of construction. The underflow system was simulated by a computer study, the results of which are tabulated. It is felt that the underflow sewer will demonstrate the feasibility of constructing economically a detention reservoir to greatly reduce the river pollution caused by overflows from combined sewers, far below the surface in public right of way, while providing the conveyance capacity to reduce basement and underpass flooding. It should also demonstrate the practicability of constructing an enlarged underflow mainstream system to serve the entire City of Chicago and the surrounding metropolitan area.

152
COMBINED SEWER STUDY.

Herbert G. Poertner.
APWA Reporter, p 6, June 1967.

Descriptors: *Surveys.
Identifiers: *Combined sewers.

A brief announcement of an FWPC contract to the APWA Research Foundation concerned with combined sewers is presented. On-site personal interviews will provide detailed information on the combined sewer systems of approximately 900 communities. Officials of all cities of over 25,000 population plus a maximum of 30% of those in smaller communities will be interviewed.

153
EFFECT OF STORM WATER ON THE SEWERAGE SYSTEM AND THE RECEIVING STREAMS.

F. Pöpel.
Kommunalwirtschaft, Vol 9, p 340, 1957.

Descriptors: *Storm runoff, *Planning, *Overflow, *Water pollution.
Identifiers: Urban drainage, *Combined sewers.

The author discusses, with special reference to planning of new towns, the effect on streams of storm water overflows in combined sewerage systems. Calculation of the permissible amount must be based on the annual amount of discharge and of polluting matter in it, the self-purifying capacity of the stream, and the use made of the stream water. Investigations are required into the condition of the storm water in modern conditions of traffic and efforts should be made to develop a reliable method of assessing the self-purifying power of a stream receiving sudden discharges of polluting matter.

154

## EXTENSIVE SEWERAGE WILL CURB POLLUTION OF A BAY.

Frederick E. Potter.
Public Works, Vol 95, pp 104-05, Oct 1946.
(through Public Health Eng Abstr, Vol 45, No 5, p 154, May 1965).

Descriptors: *Water pollution control,*Sewage treatment, Outlets, Estuaries, Construction costs.
Identifiers: *Combined sewers, *Interceptor sewers.

Article discusses the pollution problems encountered by the City of Portland, Maine. The municipality is subdivided into nine watersheds, all of which drain to tidal water outlets. The effect of tides plus combined sewerage discharge from the heavily populated areas around "Back Cove" has created an undesirable situation. Initially, a master plan was developed in 1943 to eliminate pollution within this area by construction of interceptor sewers, pumping stations, treatment plant, and outfall sewer. Recently, construction was completed on the south shore of "Back Cove" at an expenditure of approximately $1 1/2 million. Construction is expected to begin shortly on the remaining portions of the sewage treatment facilities around Back Cove Bay.

155

## THE STORM-WATER COMPROMISE.

F. J. Ribbius, and G. Kragt.
Gas Wasserfach, Vol 103, p 498, 1962.

Descriptors: *Storm runoff, *Water pollution control, *Overflow, *Design, Sewage sludge, Pumping.
Identifiers: *Combined sewers, *Dilution, *Calculations, Capacity, *Netherlands.

On the basis of experience in the Netherlands the authors discuss the design of combined sewerage systems and suitable compromise between the requirements of sewage purification and prevention of pollution of streams, with special reference to the calculation of dilution and the design of storm overflows. To avoid the risk of pollution by stirred-up sludge at storm overflows, methods are developed for calculating the frequency of overflow and the relation of storage to discharge capacity with reference to the installation of rain-water pumps. Graphs for the calculations required for the application of these principles are given and their application to projects for combined sewerage systems is discussed.

156

### IMPROVING THE EFFICIENCY OF EXISTING INTERCEPTORS.

Erik Riis-Carstensen.
Sewage Ind Wastes, Oct 1955.

Descriptors: *Storm runoff, Rainfall intensity, *Biochemical oxygen demand.
Identifiers: *Interceptor sewers, *Buffalo, N.Y., *Suspended solids, *Storage tanks.

For the Buffalo New York area, author has derived a characteristic factor for a district "Ch" which is a ratio of average dry weather flow (gpd) to the runoff (cfs) during a uniform rainfall of 1 inch/hr ($Ch = \frac{d}{c}$). Study of sewage quality or strength during a 0.55 inch rain indicates flow doubled, suspended solids 4-5 times, BOD in ppm decreased about 1/3, but total load was higher. During the rain the flow was 5 times and the suspended solids rose to 1220 ppm over an average dry weather concentration of 186 ppm. Author stresses point that the biggest contributor to the suspended solids is the material deposited in the sewers themselves during dwf. Recommends that sewers be constructed to be self-cleansing and also favors small storm water tanks be located on laterals and branches, storm water collected would augment dwf and help keep sewers clean.

157

### A BRIEF HISTORY OF POLLUTION PROBLEMS AND POLLUTION CONTROL IN THE CITY OF LONDON, ONT.

C. C. Rutherford.
Water Pollut Contr, Vol 105, No 5, pp 66-69, 71, 1967.
(through Water Pollut Abstr, Vol 41, No 5, p 218, May 1968).

Descriptors: *Water pollution, *Storm runoff, *Overflow, Water pollution control.
Identifiers: *Combined sewers, Urban drainage.

An historical description is given of pollution problems and control measures in London, Ont., which by the late 1950's was served by 3 overloaded sewage works. Problems included gross pollution of the Thames river by overflows from combined sewers, run-off from septic-tank areas, and flows from industrial sources. Subsequent annexation led to the acquisition of 3 more works; one of the original plants has been closed down and the others have been expanded and modernized. In addition, an industrial waste control program has been begun, and pollution of the river has been considerably reduced.

158

## A FLOODED-TUNNEL INTERCEPTOR SYSTEM FOR THE METROPOLITAN ST LOUIS SEWER DISTRICT.

W. G. Shifrin, G. K. Hasegawa, and V. C. Lischer.
Water Pollut Contr Fed J, Vol 39, pp 313-333, 1967.
(through Water Pollut Abstr, Vol 40, No 6, p 257, June 1967).

Descriptors: *Drainage systems, *Storm runoff, Discharge (water), Pumping, *Tunnels, Design, Construction.
Identifiers: *Interceptor sewers, *Combined sewers, *Urban drainage, St. Louis, Mo.

St. Louis, Mo., is divided into three main drainage areas, draining respectively to the Mississippi river, Coldwater creek, and Sugar creek. A new sewage works is to be constructed at Bissell Point to serve the northern part of the Mississippi river drainage area, where at present there is a combined sewerage system discharging untreated sewage and storm run-off direct to the river. The advantages and disadvantages of different types of intercepting sewer to carry the sewage to the treatment plant were studied, and it was decided to install the flooded-tunnel type, in which the sewage is allowed to rise in the wet well of the pumping station at the treatment plant to such a level that the upstream hydraulic gradient allows all diversion structures to operate with a free fall as in a gravity system. The design and construction of the interceptor system are outlined and the proposed method of operation, which will depend on river stage and weather conditions, is described in detail.

159

## HOW TO ANALYZE COMBINED SEWAGE-STORM WATER COLLECTION SYSTEMS.

R. H. Stanley.
Water Wastes Eng, Vol 3, No 3, pp 58-61, March 1966 and pp 48-50, April 1966.
(through Eng Index, p 2740, 1966).

Descriptors: *Hydraulics, *Biochemical oxygen demand, Rain, *Storm runoff, *Overflow, *Water pollution, Drainage, Computer programs.
Identifiers: *Calculations, *Combined sewers.

Method of analysis proposed involves field measurement of system hydraulic characteristics and condition. Using these hydraulic characteristics and past records of BOD levels and rainfall, overflow quantity and pollution contribution may be calculated. Proposed method is adaptable to analysis of system or drainage area changes. It can be performed economically and in relatively short period of time. Calculations involved can be handled by means of digital computer.

160

### DIVERSION FACTORS FOR COMBINED SEWERS BASED ON SEWAGE AND STREAM ANALYSES.

R. J. Theroux, and R. L. Meek.
Eng News Rec, Vol 139, p 734, 1947.

Descriptors: *Storm runoff, *Overflow, Biochemical oxygen demand, Dissolved oxygen.
Identifiers: *Combined sewers, *Interceptor sewers, *Capacity.

A rational method of determining the diversion factor for storm overflow is described in which the organic load of the sewage, in terms of BOD, is balanced against the purifying power of the stream as indicated by the flow, deoxygenation, and reaeration constants, BOD, and dissolved oxygen content of the water above the point of diversion. The method enables the maintenance of safe dissolved oxygen contents in the receiving stream without providing unneeded interceptor capacity. The diversion factor should not be less than 1.5.

161

### ONE CITY'S APPROACH TO THE PROBLEM OF COMBINED SEWAGE OVERFLOWS.

D. H. Waller.
Water Sewage Works, Vol 114, pp 113-117, 1967.
(through Water Pollut Abstr, Vol 41, No 4, p 171, April 1968).

Descriptors: *Overflow, *Sewage treatment, *Chlorination, Discharge (water).
Identifiers: *Interceptor sewers, *Storage tanks, Urban drainage, *Combined sewers.

A description is given of the design and operation of one of two retention tanks constructed to prevent overflows into Halifax harbor from the "Arm sewer", an interceptor sewer which drains the west and north-west sections of Halifax, Nova Scotia, which are served almost entirely by combined sewers. The tank, which has a capacity of 1 mil. gal, is provided with an aerated detritus tank through which dry-weather flow passes direct to the interceptor sewer after screening; but when flow in the sewer reaches a maximal level, passage through the detritus tanks is stopped, and the retention tank fills, providing 15-min detention at a design peak flow of 150 $ft^3$ per sec before over-flowing to the Arm sewer. Arrangements are made for chlorination to continue as long as the rate of inflow exceeds the rate of outflow to the interceptor. If the intensity and duration of the storm are sufficient to fill the tank, the chlorinated sewage is discharged to the harbor.

162

## THE TRUNK SEWER SYSTEM AND THE SEWAGE-TREATMENT PLANT OF THE TOWN OF UTRECHT. II. STORAGE CAPACITY OF SEWERS AND PUMP REGIME.

J. W. C. Wammis.
Ing Grav, Vol 77, G.23-G.31, 1965.
(through Water Pollut Abstr, Vol 38, No 8, p 272, Aug 1965).

Descriptors: *Flow control, *Pumping, *Sewers, Instrumentation.
Identifiers: *Combined sewers, Utrecht, Netherlands, Capacity.

The sewerage of Utrecht, Netherlands, is designed as a combined system. To obtain maximal efficiency of operation at the sewage works it is important to equalize the flow to the plant throughout the day, and this is achieved by utilizing the storage capacity of the sewers and by selecting a suitable relation between the capacities of the pumps in the various pumping stations and the numbers of hours during which they operate. The pumps are operated by remote control from the main pumping station at the sewage works.

163

## COMBINED VS SEPARATE SYSTMS OF SEWERAGE.

A. R. Ward.
Surv, Vol 81, No 2093, pp299-300, March 4, 1932.

Descriptors: *Storm runof, *Water pollution, Pumping, Sewers, *Deposition (sediments).
Identifiers: *Combined sewers.

Discussion of sewerage systems; river pollution by storm water; deposition of solids in main sewers, combined system, pumping.

164

SEWAGE WORKS DESIGN AND WET WEATHER FLOWS.

R. K. Williams, and C. G. Wells.
Inst Sewage Purif J, Pt 3, 361, 1959.

Descriptors: *Design, *Storm runoff, *Sewage treatment, *Sewage effluent, *Waste dilution, Water pollution.

The design of sewage works is usually based on the estimated dry weather flow, and the authors consider that more attention should be paid to wet weather flows. They suggest that full treatment should be provided for all flows up to 3 times dry weather flow; that flows from 3 to 5 times dry weather flow should be screened and settled; and that flows in excess of 5 times dry weather flow should be screened. In all cases the by-passed sewage should be mixed with the fully-treated effluent to dilute it before discharge. The frequency of peak flows in Salisbury, Southern Rhodesia, is discussed. The probable polluting effect of the different degrees of treatment and the effect of the suggested requirements on the design of the various treatment units are considered.

# Section V

## SEWER SYSTEMS - SANITARY

85-A

165
MUNICIPAL SEWERAGE.

Can Munic Util, pp 28-45, 88-92, 1964.
(through Eng Index, p 2237, 1965).

Descriptors: Water pollution control, *Rivers, *Design, *Construction, *Tunnels.
Identifiers: *Urban drainage.

Nine short articles by eight authors discussing various aspects of municipal sewerage, cover pollution control for small and large municipalities and sanitary sewer systems, design of sewer appurtenances, design and construction of sewers in open cut, and of tunnel sewers, and construction safety practices.

166
INFILTRATION INTO SEWERS.

New Zeal Eng, Vol 14, pp 233-238, 1959.

Descriptors: *Storm runoff, Sewers.
Identifiers: *Sewer infiltration.

In 1957 the Council of the New Zealand Institution of Engineers set up a committee to investigate into the excessive infiltration and entry of storm water into sanitary sewers. In the first report of the committee, the results of a questionnaire sent to various authorities are summarized, and conclusions drawn therefrom are studied. It appears that storm-water entry and/or infiltration is serious in 75 percent of the systems studied. It is recommended that further investigation should be made into causes of infiltration and possible remedies, including the preparation of a code of good practice in the laying of sewers and drains.

167
EXFILTRATION TESTING OF LARGE SEWERS.

Public Works, p 108, Jan 1968.

Descriptors: *Sewers, Construction.
Identifiers: *Sewer infiltration, *Sewer exfiltration.

Infiltration and exfiltration methods for ground water leakage into sewers are compared. Tests were performed on sewer pipes ranging from 27 to 72 in. Test results showed that exfiltration testing is a valuable tool in sewer construction.

168
HANDLING SANITARY SEWAGE AND STORM WATER, ROUND TABLE DISCUSSION.

Wastes Eng, Vol 31, No 4, p 215, April 1960.

Descriptors: *Storm runoff, Sewers, Settling basins, *Equipment, *Maintenance.
Identifiers: *Combined sewers.

Primarily interested in effect of storm water on flushing out of sanitary lines with resulting loss of effectiveness of grit chambers and overloading of settling tanks. Essentially an operational forum on equipment usage and effects on maintenance.

169
SEWER INFILTRATION.

Water Wastes Eng, Vol 4, No 10, p 22, Oct 1967.

Descriptors: *Sewers, Pipes, Sealants, Pumping, *Biochemical oxygen demand.
Identifiers: *Sewer infiltration, *Residential sewers, *Suspended solids.

Engineers of sewage treatment facilities in six areas of the U.S. were surveyed concerning sewer infiltration: frequency of determination of the extent of infiltration, percentage of sewer flow resulting from infiltration, steps to reduce infiltration, and effect of infiltration on the treatment plant operation. Infiltration was reported to be a problem in each area. Steps used to curb infiltration were: prompt repair of broken or damaged sewers, replacement of sewer pipe with pipes of materials better suited for the area, and enforcement of ordinances prohibiting footing drains and downspouts. High cost prevented the use of sewer linings and chemically-sealed joints. Root infestation was also a problem in each area surveyed. It is the most difficult source of infiltration to locate and correct and may account for as much as 50% of total infiltration. Infiltration affected treatment plant operation by increasing the cost of pumping and reducing BOD and suspended solids. Percentage of the total flow in the sewers resulting from infiltration was estimated to vary betwen 10 and 50 percent.

170
EFFECTS OF INFILTRATION.
Sewage Treatment Plant, Miami, Fla.
David P. Backmeyer.
Water Pollut Contr Fed J, Vol 32, No 5, pp 539-540, May 1960.

Descriptors: *Pumping, *Corrosion, *Sewers.
Identifiers: *Sewer infiltration, Florida.

The problems of infiltration of both fresh and salt water in the sewage collection and treatment plants in Florida are briefly discussed. Because of the flatness of the land many more pumping stations are necessary in Florida cities than is usual. This magnifies the overflow problem. Problems include corrosion of treatment facilities by salt and other chemicals in sea water.

171
RESIDENTIAL USE AND MISUSE OF SANITARY SEWERS.

Grant S. Bell.
Water Pollut Contr Fed J, Vol 35, Jan 1963.

Descriptors: Sewers, Cities, *Construction, *Quality control.
Identifiers: *Residential sewers.

Experience in Kentucky has already proven that it would have been much easier for the cities to have acted firmly on the matter of overloading of sanitary sewers by residence drainage than to suffer the consequences of leaving private sewers to builders' and owners' methods. Quality control of private sewer construction and regulation of the use of sewers are imperative to a totally successful sanitary sewer system.

172
## DETECTION AND SEALING OF LEAKS IN SEWERS.

B. W. Brunton.
Can Munic Util, Vol 101, No 12, pp 22-3, Dec 1963.
(through Eng Index, p 1869, 1964).

Descriptors: *Sewers, *Sealants, Equipment.
Identifiers: *Sewer infiltration.

New chemical grouting method tried in Sudbury, Ont., to repair gaps between joints in sewer system and prevent infiltration consists of TV camera and rejointer apparatus attached to cable drawn through sewer lines. When leak joint is noticed, rejointer is drawn to edge of pipe joint, then drawn required distance to have it centered at joint which is then confined and calked by remote control using chemical grouting material. Rejointer consists of hollow aluminum cylinder slightly smaller in diameter than pipe, encased in rubber jacket which is strapped to cylinder at ends and at center.

173
## PIPE JOINTS LIMIT INFILTRATION.

G. W. Clark, Jr., and M. L. Leyrer.
Civ Eng, Vol 37, No 1, pp 62-3, Jan 1967.
(through Eng Index, p 2473, 1967).

Descriptors: Sewers, Construction, *Manholes.
Identifiers: *Sewer infiltration.

City engineers in Muskegon, Mich., designed sanitary sewer trunk that would be placed in area having high water table. Limiting infiltration was most important. This was accomplished through use of rubber O-ring joint gaskets, and good construction and inspection procedures. Tests on completed line show infiltration to be between 14.5 and 55.7% of maximum allowable rate of 200 gal/in. of internal diameter per mile of pipe per day. Much of this infiltration took place at precast manhole joints, which did not have rubber O-ring joint specified.

174
THE INFILTRATION PROBLEM IN SEWAGE COLLECTION SYSTEMS.

Arthur A. DeFraites.
S W Water Works J, Vol 44, No 10, Jan 1963.

Descriptors: *Sewers.
Identifiers: *Sewer infiltration.

The author discusses the sewage infiltration problem and gives his views on how near he believes it is to being solved.

175
EXFILTRATION TESTING OF LARGE SEWERS IN KANSAS CITY, MO.

J. F. Fladung, and L. W. Weller.
Water Wastes Eng, Vol 4, No 9, pp 87-9, Sept 1967 and No 10, pp 60-63, Oct 1967.
(through Eng Index, p 256, Feb 1968).

Descriptors: Sewers, Manholes, Water pollution control.
Identifiers: *Sewer infiltration, *Leak detection, *Kansas City, Mo.

Test results discussed are for sewers constructed of reinforced concrete pipe, with manholes included in test sections. Exfiltration specification used permits leakage of 200 gal/in. of ID/mi/24 hr; data are presented on several contracts under Kansas City's pollution abatement program. Exfiltration test conditions and results are summarized.

176
AN EVALUATION OF THE PROBLEMS OF SANITARY SEWER SYSTEM DESIGN.

J. C. Geyer, and J. J. Lentz.
Water Pollut Contr Fed J, Vol 38, No 7, p 1138, July 1966.

Descriptors: *Sewers, *Design, *Storm runoff, Construction, *Groundwater.
Identifiers: *Sewer infiltration, *Residential sewers.

A study of sewer systems in four communities revealed that flow of domestic wastewater follows indoor water use and undergoes little seasonal change. Per-capita use increases with the economic status of the area. Flows of stormwater and groundwater infiltration often exceed domestic flows considerably where poor sewer construction and illicit connection to the system are prevalent. Stoppages are caused chiefly by roots and accumulated deposits, the latter especially at the upper ends of systems.

Bitumastic joints are most resistant to root penetration; newer materials have not been evaluated. Other causes of stoppages are slug discharges of grease and mud from construction.

177

ELIMINATING INFILTRATION OF GROUND WATER INTO SEWERS.

J. Godbehere.
Surv, Vol 121, 1962.

Descriptors: *Flow measurement, Sewers, *Sealants, *Groundwater.
Identifiers: *Sewer infiltration.

The author summarizes events which led to the application of Terraseal for controlling infiltration of ground water into sewers in the rural district of Amersham, Bucks. As a result of infiltration the cost of disposing of sewage, which is discharged to the West Herts Main Drainage Authority, became disproportionate to the population served. A method of assessing flow, used in river gauging, was used to determine volume of infiltration between sampling points. Initial measures to control infiltration were unsatisfactory, but a new chemical grouting process using Terraseal has resulted in a high degree of success. Terraseal is a form of sodium alginate capable of forming viscous solutions and of being converted to a stable jelly; addition of a suitable inhibitor to the solution during preparation prevents micro-organisms from attacking the jelly. The method of application is described.

178

SEWER DESIGN-INFILTRATION DETECTION AND CORRECTION.

B. J. Haney.
La State Univ - Eng Res Sta - Bull 83, pp 55-71, 1965.
(through Eng Index, p 2473, 1967).

Descriptors: *Sewers, *Design, Pipes, Construction.
Identifiers: *Sewer infiltration, Leak detection.

Calculation of capacity of sewer system, sizing of pipe, determination of pipe slope, selection of pipe material, and proper installation of pipe as basic steps in design of gravity sewer system.

179
"SMOKING OUT" ILLEGAL HOUSE DRAINS.

A. Larmon.
Wastes Eng, Vol 34, No 11, p 603, Nov 1963.

Descriptors: Sewers, Manholes, Equipment.
Identifiers: *Residential sewers, *Downspouts.

Smoke testing equipment consisting of portable 1500 cfm Homelite blower connected by canvas air-duct to sheet of 3/4-in. plywood lined with sponge rubber to fit over manhole was used to locate downspouts connected to sanitary sewer system in South Charleston, W. Va. Smoke was applied in manhole by lighting smoke bomb on suction side of blower and discharging it through manhole into sewer.

180
INFILTRATION AND SEWER FOUNDATIONS.

F. W. MacDonald, J. K. Mayer, and S. E. Steimle.
Public Works, Vol 98, No 12, pp 105-7, Dec 1967.
(through Eng Index, p 239, July 1968).

Descriptors: *Sewers, *Design.
Identifiers: *Sewer infiltration, Gulf Coast.

Study was initiated to determine most suitable foundation materials and best types of sewer arrangements, under various conditions, which will effectively decrease and control infiltration in Gulf Coast area, and to test various foundation materials and arrangements in combination with various laying conditions in order to determine most suitable bedding in number of soil types common to area.

181
INFILTRATION AND SEWER FOUNDATIONS.
Tulane Univ, New Orleans, La.
John K. Mayer, F. W. MacDonald, and S. E. Steimle.
Public Works, pp 105-107, Dec. 1967.

Descriptors: *Sewers, *Construction.
Identifiers: *Sewer infiltration, *Gulf Coast.

A study on the most suitable foundation materials and best types of sewer arrangements to decrease and control infiltration in the Gulf Coast area was carried out. Various foundation materials and arrangements under various laying conditions were tested in laboratory and field studies to determine the most suitable bedding in a number of soil types common to the area. This report covers methods of investigation and work completed in the laboratory in silty sand and fat clay with clam shell bedding.

182
REMOTE CONTROL GROUTING OF SEWER LINE LEAKS.
A. Metz, Gary, Indiana.
James Metz.
Water Wastes Eng, Vol 5, No 6, p 68, June 1968.

Descriptors: *Sewers, *Sealants, *Equipment.
Identifiers: *Sewer infiltration.

A procedure for repairing leaks in sewer lines, known as telegrout, involving the use of remote control grouting, is described. Equipment required in the process includes a van-type truck, chemical grout mixing and pumping equipment, sewer grouting packers and plugs, air compressor, television inspection components, winches, downhole sheaves, and communication system. A winch cable, to which is attached a television camera and sewer grouting packer, is pulled through the sewer line. The trailing winch line is attached to the grouting packer, and a communication line is placed between the two winches and the grouting engineer. The inline equipment is then moved through the sewer line. When a leak is observed on the television monitor, the grouting packer is set over the leak and sufficient chemical grout is pumped through the set packer to seal the leak. The grout requires 5 to 15 minutes to set. The television inspection system may also be used for survey work to determine the condition of lines before starting a repair program. Pictures can be made from the monitor screen for permanent records of lines being surveyed or repaired.

183
## LABORATORY INVESTIGATION OF SOIL INFILTRATION THROUGH PIPE JOINTS.

E. H. Nettles, and N. B. Schomaker.

Nat Res Counc - Highway Res Board - Res Rec, No 203, pp 37-56, 1967.
(through Eng Index, p 51, July 1968).

Descriptors: *Pipes, *Model studies.
Identifiers: *Sewer infiltration.

Investigation of infiltration characteristics of four soils - poorly graded medium to fine sand, uniformly graded fine sand, silt, and lean clay, to develop system of classifying soils according to degree that infiltration through pipe-joint openings may be expected to occur. Investigation included design and construction of model simulating prototype pipe joint, study of feasibility of using model for such studies, investigation of variables affecting soil infiltration, and investigation of infiltration of soils described.

184
## SEAL SEWER LEAKS FROM INSIDE.

R. Nooe.
Amer City, Vol 79, No 6, pp 91-2, June 1964.
(through Eng Index, p 1870, 1964).

Descriptors: *Sealants.
Identifiers: *Sewer infiltration.

Method recommended to repair sewers from inside using special internal injection techniques controlled and observed by TV camera. Injected chemical gel stops infiltration and is reported to lower cost of sewer rehabilitation.

185
CORRECTING STORM-WATER INFILTRATION, TONAWANDA, NEW YORK.

Newell L. Nussbaumer.
Sewage Ind Wastes, Vol 28, pp 977-82, Aug 1956.

Descriptors: *Surface runoff, *Storm drains, Sewers, *Design, Construction, Construction costs.
Identifiers: *Storm sewers, *Sewer infiltration, Tonawanda, N.Y.

The article describes the layout and construction of the early sewers in Tonawanda, N.Y. Improper planning, poor construction, lack of storm sewers, and the diversion of surface water into the sanitary sewers caused flooding of the sanitary sewers during periods of precipitation. Increased tributary population intensified sewer problems. Several attempts were made to remedy situation. In 1945 a comprehensive storm drain plan was developed to eliminate the excess water from the sanitary sewers. The types of storm sewers used, design criteria, construction details, and costs are outlined.

186
REDUCTION OF HYDRAULIC SEWER LOADING BY DOWNSPOUT REMOVAL.

Gerald L. Peters, and A. Paul Troemper.
No further identification available.

Descriptors: *Sewers, *Overflow, Storm runoff.
Identifiers: *Downspouts.

Methods used and results obtained to correct overloading of sewers by disconnecting roof downspouts from sewer systems in Springfield, Illinois are described. A description of the system existing before the program was initiated is given; data from engineering studies is presented. After the downspout removal program was decided on for suburban Springfield, inspections were made and voluntary compliance by property owners reduced the problem. Administrative and technical problems of the program for the city of Springfield are described. Results of the program are given in tables and copies of letters used are included. Costs, complaints and reduction of the overflow problem due to the program are discussed.

187

### LOW PRESSURE AIR TEST FOR SANITARY SEWERS.

Roy E. Ramseier.
ASCE Proc, J Sanit Eng Div, Vol 90, No SA2, pt 1, paper 3883, pp 1-29, April 1964.
(through Eng Index, p 1869, 1964).

Descriptors: *Sewers.
Identifiers: *Leak detection, Sewer infiltration.

Effect of moisture on permeability of vitrified clay sewer pipe and its effect on testing procedure. Specifications for testing new pipe installations are suggested, and methods of computing time necessary to meet specifications for single size pipe and for combinations of various size pipes are given. Field tests show that pipe without detectable failure will lose less than 0.003 cu ft of air/min/sq ft of internal pipe surface, and that any air loss exceeding 2 cu ft/min can be located.

188

### EXPERIENCE IN USING LOW-PRESSURE AIR TEST FOR SANITARY SEWERS.

Roy E. Ramseier, and George C. Riek.
Water Pollut Contr Fed J, Vol 38, No 10, pp 1623-33, Oct 1966.
(through Eng Index, p 2473, 1967).

Descriptors: *Sewers.
Identifiers: *Leak detection, Sewer infiltration.

Low-pressure air test for sewer leakage has proved reliable, easy to use, and inexpensive. Test, for which specifications have been developed, consists of introducing air into plugged section of pipe and measuring time needed for pressure to be reduced from 3.5 to 2.5 psi (0.24 to 0.18 kg/sq cm). Nomograph is used to compute time acceptable according to specifications. Increased wetness of pipe wall reduces air leakage through pipe-wall permeability, whereas increased pressure gradient between inside and outside of sewer increases leakage.

189

### LOW PRESSURE AIR TEST FOR SANITARY SEWERS.

Roy E. Ramseier, and George C. Riek.
ASCE Proc, J Sanit Eng Div, Vol 90, No SA2, pt 1, p 1, April 1964.

Descriptors: *Sewers, Maintenance.
Identifiers: *Leak detection.

Testing a sewer pipe for leakage by the use of air at pressures of approximately 3 psi can measure effectively the quality of the installation. New work can be tested by noting the time required for pressure in a closed section of the pipe to drop from 3.5 psi to 2.5 psi. Where significant leakage is present, it can be quantitatively determined by metering the amount of air required to maintain a pressure in the test section. The effect of moisture on the permeability of vitrified clay pipe and its effect on the testing procedure is determined. Specifications for testing new pipe installations are suggested, and methods of computing time necessary to meet specifications for a single size pipe and for combinations of various size pipes are given. Field tests show that pipe without a detectable failure will lose less than 0.003 $ft^3$ of air per min per $ft^2$ of internal pipe surface and that any air loss exceeding 2.0 $ft^3$ per min can be located.

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190

### DEPOSITION IN A SANITARY SEWER.

C. H. Raths, and R. F. McCauley.
Water Sewage Works, Vol 109, p 192, 1962.

Descriptors: *Deposition (sediments), *Sewers, Design, Construction.
Identifiers: *Suspended solids.

An investigation into deposition in sanitary sewers is described. In each experiment, an 8-in pipe line was set at the required slope, a uniform flow of sewage was produced and sand of known particle size was introduced at 8-ft intervals, in descending order of size. From the results which are shown in tables and graphs, an equation was developed to express the relation between the depth of flow, the largest size particle to pass successfully through the pipe, and the slope of the pipe. It was also found that solids suspended in the sewage apparently had little effect on deposition and that pipe joints were the principal influence in initiating deposition. It is concluded that in designing a sewer more emphasis should be placed on joints and construction techniques than on minimum pipe grades.

191
REHABILITATION OF SANITARY SEWER LINES.

D. E. Rhodes.
Water Pollut Contr Fed J, Vol 38, No 2, pp 215-19, Feb 1966.
(through Eng Index, p 2739, 1966).

Descriptors: *Sewers, Construction, Sealants.
Identifiers: *Sewer infiltration, *Leak detection, *Polymers.

Excessive infiltration into sanitary sewer lines caused by faulty construction was problem in Montgomery County, Ohio. Injection-type sealing with polymer-type grouting fluid applied within line seems to have reduced infiltration substantially. TV inspection located leaks and wastewater was diverted around plugged-off section. TV also was used for setting of packer over leaks.

192
DESIGN CONSIDERATIONS FOR SANITARY SEWER EXTENSIONS.
Mississippi State Univ, State College, Miss.
Lloyd R. Robinson.
Water Sewage Works, Vol 114, No 7, pp 250-254, July 1967.

Descriptors: *Design, *Sewers, *Storm runoff, *Overflow.
Identifiers: *Urban drainage.

The results of a study made for Kansas City to determine dry weather flows from housing developments, apartments, industries and commercial establishments are discussed. No wet weather flows were measured but in a study of the flow record at one sewage treatment plant serving a residential area, as little as 0.6 in. of rain caused the recorder capacity of 0.008 cfs/acre to be exceeded.

193
SEWERS CAN BE REBUILT BY REMOTE CONTROL.

George Rutz.
Water Works Wastes Eng, Vol 2, pp 42-43, Oct 1965. 4 photo.
(through Public Health Eng Abstr, Vol 46, No 5, p 147, May 1966).

Descriptors: *Sewers, *Sealants.
Identifiers: *Leak detection.

Sewer system leaks in approximately 3,000 ft of sewer were located by a closed-circuit television camera and then sealed with chemical "gel" by a grouting machine. The units operated from within the sewer and were controlled remotely from the surface. The TV camera provided a view of the sealing process while it was being undertaken.

194
INFILTRATION IN SANITARY SEWERS.

I. W. Santry, Jr.
Water Pollut Contr Fed J, Vol 36, p 1256, Oct 1964.

Descriptors: Sewers, Construction.
Identifiers: *Sewer infiltration.

This paper points out the importance of infiltration in sanitary sewers. The degree of infiltration is influenced by such variables as climate, soil characteristics, ground water table position, materials of construction, vegetation, and the existence of illegal connections. In this investigation submergence tests were made on clay and conrete pipe using jute, cement, cold mastic, hot pour asphalt, rubber gasket, and PVC jointing materials. It was indicated that the newer joints have much less infiltration than the older ones. The author stresses the importance of building sewers with materials that will slow down infiltration, with joints that will stay tight and with bedding and backfill conditions that will prevent future movement of the pipe. Illegal connections should be eliminated.

195
STORM WATER IN SANITARY SEWERS.

V. W. Sauer.
Sewage Ind Wastes, Vol 24, pp 166-70, 1952.

Descriptors: *Storm runoff, *Sewers.

Measures taken at Central Contra Costa Sanitary District, California, to prevent storm water entering the sewers designed to carry sewage and trade waste waters are discussed.

196
DIVERSION AND TREATMENT OF EXTRANEOUS FLOWS IN SANITARY SEWERS.

L. W. Weller, and M. K. Nelson.
Water Pollut Contr Fed J, Vol 37, p 343, 1965.

Descriptors: Sewers, *Sewage treatment, Chlorination.
Identifiers: *Sewer infiltration.

In many sewerage systems, the maximal flows may be many times the average as a result of extraneous flows, defined as liquids entering the sanitary sewers through sources other than plumbing fixtures or process facilities. This may cause difficulties at the treatment plant, and the authors describe the facilities installed to divert and treat peak flows in the Mission Township district of Johnson County, Kans. in the Indian Creek district of Johnson County and in Kansas City, Mo. Peak flows are settled, skimmed, and in two cases chlorinated, before discharge, thus reducing possible pollution of the receiving streams.

197

### A STUDY OF STORMWATER INFILTRATION INTO SANITARY SEWERS.

Lloyd W. Weller, and Myron K. Nelson.
Water Pollut Contr Fed J, Vol 35, p 762, June 1963.

Descriptors: *Storm runoff, Surface drainage.
Identifiers: *Sewer infiltration, *Urban drainage, Kansas City, Mo.

This is a discussion of the conduct and findings of a study of a sewer district with a present population of 50,000 (70,000 ultimate) located in the metropolitan area of Kansas City, Missouri. The scope and objectives of this study as regards storm-water infiltration were: "(1) to make a surface drainage survey of selected areas and a surface inspection of the main sewers to find if any conditions promote the entry of surface water into sanitary sewers, and (2) to collect and evaluate data on sewer use and sewage flows." A total sewer flow of 104.33 mgd (0.0215 cfs/acre) is developed during large rain storms and it is concluded that "even during a period of moderate precipitation the major portions of the flow are from sources other than the water-using plumbing fixtures in the residences and public buildings within the district." During these periods the major source of sewer flow is ground water, presumably from foundation drains used throughout the district. Additional local factors influencing sewer flow are reviewed.

## Section VI

## SEWER SYSTEMS - STORMWATER

198
PROVIDE DRAINAGE BEFORE FLOODS OCCUR.

Amer City, Vol 75, p 2, 1960.

Descriptors: *Storm runoff, *Water pollution, *Storm drainage, Pumping, Sewage treatment, Sewers.
Identifiers: *Storm sewers, *Urban drainage.

Present sewerage facilities serving the Counties of Macomb and Wayne, Michigan are grossly inadequate. The area is drained by Milk river which is very slow flowing and sometimes stagnant, and a rapid increase in population resulting in an increase in the volume of storm water has augmented the problem. A project to improve the sewerage facilities, started in September 1958, includes the construction of two pumping stations, a main pumping station with skimming and sedimentation tanks located about 3/4 mile upstream from the mouth of the Milk river and a low-lift pumping station about 1/2 mile downstream from the main pumping station. Radial gates have been installed in the river so that the water between the two stations can be changed when necessary. The new Milk river sewer, although designed primarily for storm water use, will carry a small quantity of sewage during storm periods. Under normal dry weather conditions all sewage is discharged to the Wayne County interceptor system and then to the Detroit sewage-treatment plant.

199
FLOOD RELIEF PROJECT IN LONDON SUBURB.

Civ Eng Public Works Rev, Vol 63, No 744, p 761, July 1968.

Descriptors: *Surface drainage, *Tunnels, *Construction, Manholes, *Velocity, Outlets, *Flood control.
Identifiers: *Sewer flushing, *London, England, *Storm sewers.

In an effort to relieve flooding in the London Borough of Redbridge a new system of surface sewers was constructed in a tunnel about 30 ft. below ground level. Access shafts were constructed of 11 ft. internal dia. reinforced concrete bolted segments. On completion of tunnelling operations they were converted into drop-manholes to transfer the excess flow from the existing system down into the new tunnel system. In addition to the connections to the existing system it was necessary to include a number of drop-manholes in the scheme since it was felt that the gradients of the new sewers should be designed so that the velocity of flow would be kept below 12 ft. per second to prevent excessive abrasion of the tunnel by grit, etc. It was found that the amount of noise produced by the flow in the drop-manholes has been low and no complaints have been received even though the manholes are sited in the road outside residential property. The flow passes down a vertical cast iron pipe into a water cushion at the bottom of the shaft. The water cushions have proved successful since although there is a build up of grit and debris at low flows, at peak flows the debris is disturbed and flushed down the pipe to the outfall. The water cushions are designed in such a way that they will not choke up with debris during prolonged low flow conditions.

200

NEW SEWERAGE FOR CROYDON.

Civ Eng Public Works Rev, Vol 63, No 743, p 666, June 1968.

Descriptors: Sewers, *Tunnels, *Construction.
Identifiers: *Storm sewers, *Capacity.

The Borough of Croydon on the border of Surrey has been carrying out a program of new building, including commercial development, which has raised a demand for additional sewage capacity. Accordingly, foul water and storm water sewerage has been laid down. The tunnel for the new sewers was sunk at a depth of 40 ft. below street level and was constructed of precast concrete segments. Tunnel diameters varied between 6 ft. and 7 ft. In the former, the foul water channel was 24 in. dia. and of 27 in. dia. in the remainder.

201

BORE DUG IN WET SOIL FLOWS TRICKY PATH.

Constr Method Equip, Vol 46, No 7, pp 140-2, 145-6, July 1964.
(through Eng Index, pp 2238-2239, 1965).

Descriptors: *Tunnel construction, Drilling equipment.
Identifiers: Storm sewers.

Methods used in building tunnel of storm sewer at Houston, Tex are outlined. Shallow 447-ft-long section by open-cut method at one end of job was first installed and then 6500 ft was excavated with wheel-type mining machine. Tunnel passes 35 to 40 ft under many streets, railroad tracks, and about 100 utility lines. Mining wheel had to go through 15-ft-wide gaps to be bordered by freeway columns later. To control wet ground, workers relied on deep wells, air pressure, and chemical grout.

202
STORM SEWER DESIGN AND ANALYSIS BY COMPUTER.

Consult Eng, Vol 30, No 7, pp 78, 81, July 1966.
(through Eng Index, p 2474, 1967).

Descriptors: *Design, Overflow, Outlets, Computer programs.
Identifiers: *Storm sewers.

Three ways in which computer program can solve problems related to storm sewer design and analysis: in analyzing existing system for each pipe, output contains indication of overloading, together with measure of surcharge; by redesigning existing system, program analyzes existing system and, if any pipe is surcharged, it indicates surcharge and calculates correct size for that pipe by adding small increments to cross sectional area; new system design in which each pipe is considered separately, outfall of pipe under consideration being taken as outfall of network upstream of this point.

203
HIGHWAY BRIDGE MEN BUILD TUNNEL-FOR WATER.

Eng News Rec, Vol 174, No. 15, pp 34-6, Apr 15, 1965.
(through Eng Index, p 2239, 1965).

Descriptors: Drilling equipment, *Tunnel construction, Storm drains, Outlets.
Identifiers: Storm sewers, Urban drainage.

Construction of 4.29 mi bored trunk storm drain for Interstate Route 280 in New Jersey that is depressed through Newark, East Orange and Orange is described. Drain will carry water from these areas to outfall in Passaic River. Sewer has circular cross section 8-ft in diam, its wall is 1-ft-thick cast-in-place concrete. For 3.86 mi, its depth below existing ground level ranges from 35 to 73 ft and averages about 60 ft.

204
PLANNED CITY PLANS TO RE-USE STORM RUNOFF.

Environ Sci Technol, Vol 1, No 11, p 875, Nov 1967.

Descriptors: *Water reuse, *Storm runoff, *Water pollution control, Equipment, Sewage treatment.
Identifiers: *Storage tanks, *Urban drainage, *Columbia, Md.

A plan to store storm water locally, thus controlling pollution, and then to amortize construction costs by reusing the water for high-volume needs is being studied in the planned city of Columbia, Maryland. The plan calls for collecting rain runoff in neighborhood reservoirs, or even in mass produced storage basins for individual residences. Methods and equipment for treating the water to make it suitable for non-drinking purposes are also being studied.

205
UTILIZATION OF STREAM FOR STREAM DAMAGE.

Public Works, April 1967.

Descriptors: *Drainage systems, *Storm drains, Sewers, Storm runoff.
Identifiers: *Urban drainage.

A municipality is legally liable for defects and obstructions in sewers and drains whether a natural watercourse is adopted for drainage purposes or an artificial channel is built. A legal case illustrating this point is discussed wherein the city was proved liable for water damage when a rainstorm backed up waters in a stream used as part of the city's storm drainage system.

206

STANDARDS FOR STORM-WATER FACILITIES.

Public Works, Vol 91, No 2, p 91, 1960.

Descriptors: *Standards, *Storm runoff, Design, Maintenance.
Identifiers: *Storm sewers, *St. Louis, Mo., *Urban drainage.

The new standards for storm-water channels, established by the St. Louis Metropolitan Sewer District in order to reduce erosion and reduce maintenance costs and to provide definite data for storm sewer and ditch design, are outlined with the aid of diagrams.

207

PING-PONG BALLS WILL TRACE POLLUTION.

Sewage Works Eng., Vol 19, p 450, Sept 1948.

Descriptors: Water pollution, *Tracers, *Sewers.
Identifiers: *Storm sewers.

Champaign-Urbana, Ill., is faced with a storm sewer problem which has apparently resulted in pollution of an area referred to as the Boneyard. The lack of funds in the budgets of the two cities has delayed a survey of the storm sewer system, but a study of sections of the sewers will be started immediately. The work will be carried out under the direction of Walter M. Kunsch, engineer-manager of the Champaign-Urbana Sanitary District. The check will be made by dropping ping-pong balls or other floating matter down toilets in the area drained by certain sections of the doubtful storm sewer system. If the balls turn up at the Boneyard, outlet for the storm sewer system, rather than at the sewage treatment plant of the Sanitary District, it will be evident that sanitary sewage is cross-connected to the storm sewers. The homes from which the ping-pong balls were discharged will be traced and the pollution corrected.

208
£2 1/2 m FLOOD RELIEF SCHEME FOR WEST LONDON.

Surv, Vol 122, No 3728, p 1429, Nov 16, 1963.
(through Eng Index, p 1870, 1964).

Descriptors: Pumping, Storm runoff.
Identifiers: *Storm sewers, London, England.

Extensions to existing flood relief system in West London include Hammersmith storm relief sewer and pumping station. New station will contain 8 electrically driven 42-in.-diam pumps with total capacity of 1500 tons/min. Just before pumping station, 6-ft and 2 8-ft sewers will combine into approach channel 24 ft wide and 120 ft long which will house penstocks and screens to protect pumps.

209
PROCEEDINGS OF THE THIRTEENTH CONFERENCE OF LOCAL AUTHORITY ENGINEERS, QUEENSLAND, 1962.
Queensland Dep of Local Government.

Government Printer, Brisbane. 190 pp.
(through Water Pollut Abstr, Vol 38, No 4, p 109, April 1965).

Descriptors: *Design, *Construction, *Drainage systems, *Storm runoff, Sewers.
Identifiers: *Storm sewers.

This publication contains the full text of papers and discussions presented at a conference in Brisbane, October 1962, dealing with various subjects of concern to local authority engineers, including the design, construction, and maintenance of mild-steel reservoirs; service pipes for water-distribution systems; design, construction, and maintenance of open drains (both lined and unlined), including irrigation channels; materials for sewers and methods of jointing; dewatering of wet ground, including methods for lowering the water table; and the design and construction of storm-water drainage systems.

210
SURFACE WATER AND SUBSOIL DRAINAGE.
British Standards Instn, London.

Council for Codes of Practice for Buildings, British Standard Code of Practice CP 303, 1952.

Descriptors: *Storm drains, *Design, *Surface drainage, *Rainfall intensity.
Identifiers: *Storm sewers, Urban drainage, *Surface permeability, Storage tanks.

In this Code of Practice on drainage, recommendations are made for the collection and disposal of rain water and subsoil water, particularly by sewers and drains from small housing estates and individual dwellings. Factors to be considered in the design of surface-water drainage systems so that pipes are self-cleaning are the intensity and duration of rain fall and permeability of surfaces. Procedure is given for disposal of water in sewerage system or to soakaways, streams, or storage vessels. Subsoil water is defined as the portion of rainfall that is absorbed in the ground and its drainage is required to increase the stability of the surface and workability of soil and to reduce flooding. The laying of field drains and mole drains is dealt with in relation to local conditions.

211
A GUIDE FOR ENGINEERS TO THE DESIGN OF STORM SEWER SYSTEMS, PREFACED BY THE REPORT OF THE JOINT COMMITTEE ON RAINFALL AND RUN-OFF OF THE ROAD RESEARCH BOARD AND THE MINISTRY OF HOUSING AND LOCAL GOVERNMENT.

Dep Sci Ind Res, Road Res Lab, Road Note No 35, 1963. H. M. Stationery Office, London.

Descriptors: *Design, *Hydrographs, *Hydraulic properties, Sewers, Pipes, Computer programs, *Runoff, *Rainfall intensity.
Identifiers: *Storm sewers, *Lloyd-Davies formula.

This publication is intended to guide engineers in the use of the 'rational' (Lloyd-Davies) formula and the Road Research Laboratory hydrograph method for designing storm sewage systems. The 'rational' formula is recommended for use in areas where the diameter of the largest sewer is unlikely to exceed 24 inches, while the R.R.L. hydrograph method is applicable to all areas. The calculations involved in the hydrograph method are carried out by means of an electronic digital computer. Data on rates of rainfall and the hydraulic characteristics of sewer pipes are included. The publication is prefaced with a report of the Joint Committee on Rainfall and Run-off of the Road Research Board and the Ministry of Housing and Local Government, dealing with origins of the research, constitution and terms of reference of the committee, and the work being carried out.

212
SMALL UNDERGROUND DRAINS AND SEWERS: I AND II.

Dept Sci Ind Res, Build Res Sta, Dig Nos 124 and 125. 1959.

Descriptors: *Design, *Construction, *Sewers.

These Digests, which supersede Digest No. 55 (1953), contain advice on the design and construction of drains and sewers, revised on the basis of recent studies. Part I deals with structural design, and Part II with watertightness, flexible joints, site work, and testing.

213
THIRTEENTH ANNUAL REPORT, 1963-64.
Mersey River Board.

78 pp, 8 plates, 2 maps.
(through Water Pollut Abstr, Vol 39, No 5, p 149, May 1966).

Descriptors: *Water pollution control.
Identifiers: *Storm sewers, Great Britain.

This report of the Mersey River Board, which is to be superseded by the Mersey and Weaver River Authority, includes a section on the prevention of pollution; a map showing the general condition of rivers and streams in the area, according to a color-coding scheme; and tabulated data obtained in river surveys. Quarterly chemical surveys of all the major rivers showed a slight improvement in water quality as compared with the previous year and with 6 of the previous 8 years. Sources of pollution and remedial action are outlined and detailed observations are reported on the river Alt, Ditton brook, Sankey brook and Glaze brook. The Board encourages the centralized treatment of sewage in larger plants, the discharge of trade waste waters to sewers, and the construction of separate storm-sewage systems. Observations are being continued on the self-purification and re-oxygenation which occur when a polluted stream passes through a large lake.

214
STORM DRAINAGE SYSTEMS.

U S Dep of the Navy, Bureau of Yards and Docks. U S Dep Comm, Office of Tech Services, Washington, D C, 1956.

Descriptors: *Storm drains, *Storm runoff, Subsurface drainage, *Design, *Construction, *Maintenance.

This revised publication presents in detail basic information on the design, construction and maintenance of storm drainage systems used at naval establishments in the U.S.A. and abroad. Although sub-surface drainage factors are presented, a sub-surface system should be required only when excess water cannot be otherwise removed.

215
ESTIMATING THE CAPACITY OF SEWERS AND STORM DRAINS.

P. Ackers.
Munic Eng, Vol 142, p 170, 175, 1965.
(through Water Pollut Abstr, Vol 39, No 8, p 267, Aug 1966).

Descriptors: *Sewers, *Storm drains, Pipes, Flow measurement, Slime.
Identifiers: *Capacity.

Recent investigations on sewer capacities, conducted at the Ministry of Technology, Hydraulics Research Station, are summarized. Experiments using clean, salt-glazed, precast concrete, and pitch-fiber pipes confirmed the validity of the Colebrook-White friction formula (but not the Crimp and Bruges or Manning equations), and also showed that pitch-fiber pipes, when clean, have an hydraulic capacity 5-10 percent greater than the others. The effect of imperfect joints in salt-glazed pipes on the roughness coefficient was found to be directly related to the degree of eccentricity and the spacing of the joints. To investigate the effect of slime layers, flow-velocity measurements were made in 20 sewers of various ages, materials, sizes and gradients, and the roughness coefficients were calculated. The results, which are tabulated, indicate that slime layers form quite rapidly in sewers, and that the roughness factor increases with increasing thickness of the layer, giving a corresponding reduction in capacity.

216

### EFFECTS OF USE ON THE HYDRAULIC RESISTANCE OF DRAINAGE CONDUITS.

P. Ackers, M. J. Crickmore, and D. W. Holmes.
Inst Civ Eng Proc, Vol 38, Pap No 6743, pp 339-359, 1964.
(through Water Pollut Abstr, Vol 38, No 1, p 17, Jan 1965).

Descriptors: *Pipes, Drainage systems, Conduits, Roughness (hydraulic), *Aging (physical), Deterioration.
Identifiers: *Capacity.

As a sequel to studies on the hydraulic roughness of new sewer pipes field experiments were carried out to obtain information on the probable deterioration of capacity with age and use. The studies, in which both salt-velocity and radioactive-tracer techniques were used (the iodine-132 method being found most convenient for use in sewers), were carried out at 20 sites giving a wide range of pipe materials, sizes, gradients, and degrees of sliming; and roughness values were calculated using the Colebrook-White equation for turbulent flow. Slime became established in sewers after a relatively short period of use and tended to predominate near the normal water level, but the degree of sliming varied considerably at the different sites, probably depending on the composition of the sewage as well as the boundary shear. Layers of slime less than 1/8-inch thick had little effect on the resistance to flow or the capacity of the pipe, but above this level the resistance to flow increased rapidly with thickness of slime. Compared with slime, the presence of sediment in the invert had more marked effects on the roughness values particularly under conditions such that standing waves were produced. The effects of sediment varied widely depending on the "bed form" (a function of particle size) and the flow conditions. Based on the experimental results, roughness values are recommended for mature foul sewers.

217

### MANUAL FOR URBAN PLANNING - CHAPTER V: INDUSTRIAL LAND PLANNING.

J. Byron Barber.
ASCE Proc, J Urban Planning Devel Div, Vol 93, No UP3, pp 1-13, Sept, 1967.

Descriptors: *Planning, *Drainage systems, Surface runoff, *Storm runoff.
Identifiers: *Urban drainage.

Two aspects of industrial land planning are presented: (1) The urban planner responsible for ascertaining amounts, kinds, and locations of industrial land in the general plan; and (2) the industrial land planner responsible for selection and formulation of a plan for a specific site for a manufacturing plant. It is emphasized that the principles, objectives, methods, and standards described herein apply to both aspects. Sewage problems are briefly discussed. Costs depend on the characteristics of the land and on the type of industry. Storm drainage and surface runoff should be separated from industrial and domestic wastes.

218
ECONOMICS OF URBAN DRAINAGE DESIGN.

W. J. Bauer.
ASCE Proc, J Hydraul Div, Vol 88, No HY 6, pp 93-114, 1962.

Descriptors: Land use, Design storm, *Storm runoff.
Identifiers: *Urban drainage, *Storm sewers, *Chicago, Ill., Capacity.

Problem of urban drainage viewed as one of space allocation. Storm sewers need a system of controlling location of volumes of water that occupy space in a watershed during and after periods of excessive rainfall. Principles are illustrated by application to Chicago Metropolitan Area during storm of July 1957. Idea of measuring performance of conveyance system in terms of dollars/cfs in transporting water is introduced and some sewer costs given. Planning criteria for urban drainage given: design storm, future urbanization, multiple-purpose projects, storm sewer capacity, assessing benefits, regulation of use of flood plain.

219
MANUAL ON URBAN PLANNING - CHAPTER III: RESIDENTIAL LAND PLANNING.
George C Bestor & Assocs, Inc, Carmel, Calif.
George G. Bestor.
ASCE Proc, J Urban Planning Devel Div, Vol 93, No UP2, pp 27-92,
June 1967.

Descriptors: *Planning, Land use, Storm drains, *Drainage systems,
*Storm runoff.
Identifiers: *Urban drainage.

Residential land planning is going through an era of drastic change. The creation of a better living environment is a major challenge to planners. Engineers are needed as specialists supporting planning activities, and as qualified planners. Many concepts in planning are being increasingly employed, such as: clustering, density zoning, open space, recreational features. Careful consideration of economics is essential to a succesful planning activity. No matter how well planned, a project can fail to obtain approval from sponsors or from governing authorities if it is poorly explained and presented. Storm drainage should be planned in the early stages of a project development. Several methods of dealing with stormwater are outlined.

220
### STORM SEWER TUNNEL IN ST. PAUL.

J. W. Bird.
Civ Eng, Vol 33, pp 51-53, Sept 1963.

Descriptors: *Tunnels, Construction, Construction costs.
Identifiers: *Storm sewers, *St. Paul, Minn., "Mole" tunneling.

St. Paul's storm sewer tunnel involved building 4,800 ft of 10-ft tunnel with 12-in. walls and 1,200 ft of 7-ft tunnel and 900 ft of 6-ft tunnel with 9-in. walls. The cost was $2,120,852. There are three 36-in., one 4-ft, and one 8-ft dropshafts. Four 10-in. alignment holes were drilled to a depth of 70 ft below the tunnel. These holes acted as inverted walls and were used to lower the water table and to provide construction needs. A 20-ft long mechanical mole excavated a 12-ft 3-in. opening for the 10-ft tunnel. Excavated material was transported to a slurry box, mixed with water to constitute 20 percent solids, and pumped out. Dust problems were solved by a water-spray and air-exhaust system. Placing forms and pouring concrete closely followed the excavation. Only 110 to 200 ft of unlined tunnel was permitted. A pneumatic concrete placing machine was replaced by a Pumperete machine that cut concrete placement time in half. Vibrators in the concrete plus some vibration in the forms gave excellent results.

221
### TORONTO CONFRONTS OUTDATED SEWERS.

F. T. Booth, N. Vardin, and G. L. Ball.
Water Pollut Contr Fed J, Vol 39, No 9, p 1557, Sept 1967.

Descriptors: *Storm runoff, *Water pollution control, Construction, *Overflow, Highways.
Identifiers: *Combined sewers, Toronto, Canada, *Capacity, *Storm sewers.

Toronto's combined sewer system is inadequate to handle the flows generated by storms. A program to correct this problem is now under way. Separation of sanitary waste flows and drainage is required in all new buildings. It was determined that a stormwater capacity of about 1.5 times dry-weather flow provides substantial reduction in pollution from storm overflows without excessive cost. Construction of shallow storm sewers will be undertaken to first intercept road and other land runoff and later to receive separate drainage flows from buildings as redevelopment takes place. The proposed system ultimately will protect against the storm with a return period of one year.

222
THE MAUNGARAKI DEVELOPMENT.

R. G. Brickell.
New Zeal Eng, Vol 23, No 3, pp 95-100, Mar 15, 1968.

Descriptors: *Storm runoff, Flood control, Discharge (water).
Identifiers: *Urban drainage, *Capacity.

A development of hilly land for housing in the Wellington area in New Zealand, known as the Maungaraki Development, is described. Problems arising from the development include finance, erosion control, compaction control, and removal of unsuitable materials. The disposal of stormwater runoff was complicated by the limitation of peak runoffs reaching the main stormwater system (the Western Hills culvert) to the capacity of the culvert. The problem was solved by the use in the two main valleys of flood control dams, which store the flood waters and let them discharge at a controlled rate. The ponds are carefully fenced off and are provided with "leaks" at a low level, which ensure that they dry out a few days after rain. The second flood control dam, in Percy Creek, was constructed by the Petone Borough Council to a design prepared by Climie, Spencer, and Associates, consulting engineers to the Petone Borough Council.

223
EPOXY SOLVES HAZARDOUS SEWER LINING PROBLEM.

F. V. Cornelius.
Public Works, Vol 98, No 1, p 126, Jan 1967.
(through Eng Index, p 2473, 1967).

Descriptors: Sewers, *Sealants.
Identifiers: *Storm sewers, Polymers.

Utilization of epoxy materials for lining large storm sewer following explosion while heating asphalt mixture for lining is described. Commercial Chem Co, Cincinnati, Ohio, supplied Epo-Patch and Epo-Surfacer compounds to trowel in invert and spray top part of corrugated pipe. Thickness of epoxy application ranged from 10 mils to 6 in. Approximately 82 gal were required for complete lining of sewer.

224
RETENTION BASIN ELIMINATES NEED FOR COSTLY STORM SEWERS.

F. W. Crane.
Eng News Rec, Vol 143, No 25, pp 38-42, 1949.

Descriptors: *Flood control, *Storm runoff, Pumping.
Identifiers: *Storm sewers, Buffalo, N.Y., *Storage tanks, Capacity.

To prevent flooding from overloaded storm sewers in Buffalo, New York, it is planned to store excess storm water in a disused quarry which has a capacity of 2,350,000 cu ft. The water will then be pumped gradually into the sewers and so discharged into the creek.

225
STORM WATER DETENTION IN URBAN AREAS.

Eugene J. Daily.
Public Works, Vol 92, pp 146-147, Jan 1961.

Descriptors: Storm runoff, Drainage system.
Identifiers: *Urban drainage, *Storage tanks.

Some cost estimates of savings in drainage systems by using detention basins are given.

226
DESIGN STORM HYETOGRAPHS FROM STUDIES OF RAINFALL IN THE WESTERN AREA OF SIERRA LEONE.

E. J. Davies, N. J. Garber, and A. E. Harleston.
Inst Water Eng J, Vol 20, No 1, pp 67-74, Feb 1966. 5 fig, 9 ref.
(through Public Health Eng Abstr, Vol 46, No 6, p 199, June 1966).

Descriptors: *Design storm, *Drainage systems, *Rainfall intensity, Design, Storm, *Hydraulic design.

In Sierra Leone, the design of stormwater drains, spillways, and similar structures whose geometric and hydraulic properties must be related to precipitation frequency, intensity, and duration has largely been based on conjectural storm characteristics. The object of the study was to produce predesign information applicable to the design of stormwater drains and similar structures.

227
DETERMINATION OF VARIABLE MAXIMAL INTENSITY COEFFICIENTS FOR STORM-SEWER CALCULATIONS.

L. T. Epshtien.
Vodosn Sanit Tekh, No 5, p 15, 1960.

Descriptors: *Rainfall intensity, *Rainfall-runoff relationships, Design, Storm runoff.
Identifiers: *Storm sewers.

The author discusses a method for determining the coefficient of variable maximal intensities, or relative reduction in run-off intensities for individual collectors, for use in designing storm-water sewers.

228
DESIGN OF SURFACE-WATER SEWERS.

L. B. Escritt.
CR Books Ltd, London, 1964. 64 pp.
(through Water Pollut Abstr, Vol 38, No 3, p 83, March 1965.

Descriptors: *Design.
Identifiers: *Storm sewers, Calculations.

In this Monograph, which is largely based on a previous paper by L. B. Escritt, and A. J. M. Young with modifications in the light of further research, recommendations are made for the economical design of surface-water sewers. After a critical review of previous practice, experience, and research, with particular reference to errors resulting in the considerable over-sizing of sewers, the theory is re-examined in the light of recent field studies, leading to the development of a simple, rapid, and accurate method for designing sewers of more economical sizes. Examples are given comparing the new method with the original Lloyd-Davies method. A list of references is provided.

229
SURFACE WATER DRAINAGE CALCULATION BY DIGITAL COMPUTER.

J. G. Evans.
Surv, Vol 121, pp 1436-1437, 1962.
(through Water Pollut Abstr, Vol 37, No 5, p 162, May 1964).

Descriptors: *Surface drainage, *Computer programs, Runoff, Rainfall intensity.
Identifiers: *Calculations.

The author has devised a computer program for calculating the drainage requirements of any area (involving pipe sizes not exceeding 33 inches in diameter), based on the conventional Lloyd Davies formula. The computer has been used successfully to record rainfall and run-off measurements for the drainage areas of Cwmbran new town.

230

## CALCULATION OF STORM-SEWAGE TANKS.

H. Fischer.
Gas Wasserfach, Vol 105, pp 543-544, 1964.
(through Water Pollut Abstr, Vol 39, No 3, p 94, March 1966).

Descriptors: *Storm runoff, Design, Overflow, Discharge (water).
Identifiers: *Storage tanks, *Calculations, *Capacity.

In connection with the design of storm-sewage tanks for the Rheingönheim area of Ludwigshafen, investigations were carried out on the frequency of action of storm-sewage overflows and the characteristics which should be considered when calculating the discharge after the peak load. Results showed that the characteristics of the flow record can be very variable for different periods of rain even if the maximum coefficient remains the same. The author presents graphs and a chart for a simplified calculation of discharge from storm-sewage overflows and gives a numerical example which can be adapted to any particular characteristic of discharge.

231

## MAIN DRAINAGE FOR SKELMERSDALE NEW TOWN.

D. H. Garside.
Inst Munic Eng J, Vol 93, pp 26-27, 1966.
(through Water Pollut Abstr, Vol 40, No 4, p 166, Apr 1967).

Descriptors: Sewers, *Hydrographs, Sewage treatment, Sewage effluent, Design.
Identifiers: *Combined sewers, *Sewer separation, *Storm sewers.

The sewerage system for Skelmersdale New Town, Lancs., has been designed on a separate system and, wherever possible, existing combined sewers will be replaced by separate foul and surface-water systems. After making a comparison between the Road Research Laboratory Hydrograph, and the Lloyd-Davies method of design for surface-water sewers, it was decided to adopt mainly the Lloyd-Davies method, but the R.R.L. method was used to produce the hydrographs required for the design of the balancing lakes. There are three types of temporary treatment plant in use: one a package-type extended-aeration plant; the second, an extended-aeration plant using diffused air; and the third a conventional filter plant using "Flocor" medium. The final effluent is discharged to the river Tawd. A fourth plant is planned, in the event of further housing development or an increase in industrial flow; this will involve primary sedimentation, land treatment, and clarification of the final effluent through a gravel bed, and the effluent will be discharged to the river Tawd. The main sewage works which is being constructed will provide complete treatment by the activated-sludge process with Simcar aeration cones, and the effluent will be discharged to the river Douglas.

232
HOW TO ESTIMATE STORM WATER QUANTITIES.

H. M. Gifft, and G. E. Symons.
Water Wastes Eng, Vol 5, No 3, pp 46-50, Mar 1968.
(through Eng Index, p 244, June 1968).

Descriptors: *Storm runoff, *Rainfall intensity, Design, Drainage.
Identifiers: *Storm sewers, *Capacity, Calculations.

Several factors involved in determining quantities of storm water are discussed for storm sewer design as related to rainfall and runoff. Derivation of formulas for calculation of drainage area shape, rainfall intensity-frequency data, time of concentration, and coefficient of runoff. Nomograph for determining inlet time of flow.

233
MAIN DRAINAGE OF LEYTON.

J. B. Glover.
Chartered Munic Eng, Vol 91, No 2, pp 59-63, Feb 1964.
(through Eng Index, p 1869, 1964).

Descriptors: *Sewers, *Design, Surface runoff, Outlets.
Identifiers: *Storm sewers.

Proposed improvement scheme for sewer system in Leyton, England, includes construction of trunk foul water and surface water sewers and 3 short spurs, and reconstruction of main outfall system; basis of design.

234

## MANUAL ON URBAN PLANNING - CHAPTER VI: COMMUNITY FACILITIES PLANNING.

Herbert A. Goetsch.
ASCE Proc, J Urban Planning Devel Div, Vol 93, No UP3, pp 15-42,
Sept 1967.

Descriptors: Sewage treatment, *Flood control, *Planning, Storm runoff, *Drainage systems.
Identifiers: *Urban drainage.

Community facilities are those buildings, works and land areas which are devoted to public or semi-public uses. Included in this category are public works and utilities to provide water, power, heat, light, communications, sewage treatment, flood control, and transportation. In planning for community facilities, the urban planner must consider population characteristics and projections, present and future land use, local governmental structures, climate, topography, soil, and vegetation. He must consider a community's objectives and financial ability, as well as the standards of the using agencies. Community facilities may be provided by a local community alone, jointly by several units of government, by higher levels of government, by utility comanies, and by private and semi-private agencies. These facilities should be planned jointly since their uses are often complementary and space can be conserved. Problems of flood control and stormwater drainage systems are discussed. Providing adequate stormwater drainage must be considered an important part of urban planning. Economic and engineering aspects of the problem are outlined.

235

## CONSIDERATION OF STORAGE CAPACITY IN STORM-WATER SEWERS.

J. F. Gruhler.
Gesundh Ing, Vol 84, 1963.

Descriptors: Design, *Instrumentation, *Flood control, *Storm runoff.
Identifiers: *Storm sewers, Capacity.

The author describes the design of a storm-water sewer equipped with special throttles which can be arranged so as to use the total storage capacity of the sewer and at the same time control the volume of storm water leaving the system to avoid flooding. The exact position and size of these throttles must be determined experimentally, since there is at present no known method for calculating them. The principle of the design is based on the establishment of equilibrium conditions, the flow of storm water entering the system being equal to the storage capacity of the system minus the storm water leaving it, and this depends on the sewer being filled to a certain depth.

236
ON-THE-SPOT TESTS CHECK GUTTER CAPACITY.

G. H. Hamlin, and J. Bautista.
Amer City, Vol 80, No 4, pp 94-6, April 1965.
(through Eng Index, p 2578, 1966).

Descriptors: Flow measurement, *Surface runoff, *Overflow, Design storm, *Inlets.
Identifiers: *Street gutters, *Capacity.

Water-carrying capacity of street gutters in San Leandro, Calif. was tested and it was found that practical flows are 1/2 to 1/4 of maximum calculated flows. Measurements show that overflows occur substantially below maximums found in tables or calculated by formula. Overflows are caused by vehicles parked at curb and driveway openings. Tests also measured curb inlet and grating performance. Catchbasins are now installed wherever design-storm flow reaches half-way up vertical curb face on all street grades up to 5 percent.

237
THE DESIGN OF STORM SEWERS.

J. G. Hendrickson, and T. K. Breitfuss.
Public Works, Vol 87, No 2, pp 91-5, 1956.

Descriptors: Design, *Runoff forecasting, Rainfall intensity, *Storm runoff, Construction, *Intakes, *Outlets, *Manholes.
Identifiers: *Storm sewers, *Capacity.

The calculation of run-off, which is dependent upon intensity, duration, and direction of rainstorms and slope and condition of surface of area to be served, is a very important factor in design of storm sewers. Storm run-off formulae and calculation of run-off are discussed. The authors consider also the design and construction of different types of inlets and outlets for storm sewers, design and location of manholes, and the load-carrying capacity of sewer pipes.

238
STORM SEWER DESIGN BY THE INLET METHOD.

Albert B. Kaltenbach.
Public Works, Vol 94, Jan 1963.

Descriptors: *Design, *Intakes, *Storm drains, *Rainfall intensity, Hydrographs, Flow measurement.
Identifiers: *Storm sewers.

The Inlet Method of Design for storm sewers was developed from a continuing research project on storm drains that has been carried on by the Johns Hopkins University for the past 13 years. The article reports this method has shown results closer to and more consistent with actual conditions than any other known design method. The 3 steps involved are (1) determination of peak flows to each inlet based on maximum 5 minute rainfall intensity; (2) attenuating the flow peak from sub-area as it moves down the pipe; and (3) summing each sub-area hydrograph to determine the total hydrograph at the design point. A simplified procedure is given for the designs where many inlets are involved.

239
[USE OF 3m DIAM REINFORCED CONCRETE STORM SEWERS FOR WESTERN SIBERIAN METALLURGICAL PLANT, SOVIET UNION]. Primenenie zhelezobetonnykh trub diametrom 3 m dlya promyshlenno-livnevogo kollektora ZSMS. (in Russian).

G. E. Korotkovskii, Yu. M. Sedel'nitskii, and M. M. Tanakov.
Beton i Zhelezobeton, No 9, pp 8-12, Sept 1967.
(through Eng Index, p 163, April 1968).

Descriptors: *Design.
Identifiers: *Storm sewers, Russia.

Transverse reinforcement in 3 m sewers must be designed under high loads considering resistance of transverse and shearing force by concrete and reinforcement. Each annular rod in tension zone should be fastened by ties. Side earth pressure up to 20 percent of vertical load leads to increase of bearing capacity of sewer and should be considered during design. Good agreement between theoretical and experimental values.

240

### OIL RETENTION IN STORM-SEWAGE PUMPING STATIONS AND STORM-SEWAGE TANKS.

A. Krauel.
Gas Wasserfach, Vol 108, pp 48-51, 1967.
(through Water Pollut Abstr, Vol 40, No 7, p 291, July 1967).

Descriptors: *Design, *Pumping, *Storm runoff, Water pollution control.
Identifiers: Ruhr River, Germany.

A description, with diagrams, is given of the design and operation of various storm-sewage pumping works, which were installed at 60 points on the lower Ruhr against oil pollution. These works, and the oil separators incorporated, are designed in accordance with the total rainfall of the area. Special reference is made to a reinforced-concrete oil separator, installed at the inlet of a large earth reservoir to prevent pollution of the ground water.

241

### LEAVES WON'T CLOG THIS CATCH BASIN.

R. E. Lapar.
Public Works, Vol 95, No 3, pp 90-1, March 1964.
(through Eng Index, p 1870, 1964).

Descriptors: *Storm runoff, *Intakes, Design.
Identifiers: *Storm sewers, Urban drainage.

Storm sewer project in Poughkeepsie, N.Y., required new design for street catch basins which incorporates depressed stream flow grate with extra wide curb opening. Grating used has distinct advantage of offering teardrop construction of cross-bars which minimizes tendency to retain leaves at surface and induce clogging.

242

## INDUSTRIAL AND DOMESTIC WASTEWATER CONTROL IN THE MILWAUKEE METROPOLITAN DISTRICT.

R. D. Leary, and L. A. Ernest.
Water Pollut Contr Fed J, Vol 39, No 7, p 1223, July 1967.

Descriptors: *Sewers, *Sewage treatment, Water pollution.
Identifiers: *Storm sewers, Urban drainage, Milwaukee, Wis.

The Milwaukee Sewerage Commission provides wastewater collection and treatment facilities for the 18 municipalities located within the District as well as for 7 contract areas located within the drainage area. Industries are required to separate wastewaters for discharge to storm or sanitary sewers and where necessary to provide pretreatment. Separation of unpolluted and slightly polluted industrial wastewaters for discharge to storm sewers is stressed to reduce the volume requiring treatment. This philosophy is carried into the domestic wastewater area and separation is required on private property. Concentrated wastewaters which will not affect adversely the collection system or the treatment processes are accepted in the sanitary sewer system. Required industrial waste pretreatment facilities are therefore designed to remove prohibited materials from the wastewater and generally can be classed as primary treatment units.

243

## HOW TO SIZE CONDUITS FOR STORM SEWERS.

Chesman A. Lee.
Chem Eng, Vol 67, No 20, pp 97-8, Oct 3, 1960.

Descriptors: Sewers, *Design, *Overflow.
Identifiers: *Storm sewers, *Manning formula.

A chemical plant must be supplied with storm as well as sanitary sewers. In general, sewers are designed to operate only partially full--quite different from the techniques of operating pipe lines full and under pressure. The Manning formula is discussed in considerable detail. A storm sewer may be designed to operate full and overflowing under the worst conditions. The fact that the sewer is under pressure need cause no concern since at times of heavy rains the soil is saturated and provides an opposing pressure. A problem and its step-by-step solution is given to illustrate methods used to provide design data.

244
A NEW WASTE DISPOSAL SYSTEM.

E. Lindstrom.
Tidskr värme - vent-sanit-o kyl Tek, Vol 29, pp 211-213, 230, 1958.
(through Water Pollut Abstr, Vol 40, No 6, p 256, June 1967).

Descriptors: *Sewage treatment, *Plastic pipes, Storm runoff.
Identifiers: *Storm sewers.

In the proposed system, sewage from toilets is discharged separately from other household waste water by means of a vacuum maintained in the sewer, using a very small quantity of water to rinse the toilet bowl and form a water trap. The small amount of highly-concentrated sewage obtained would receive conventional treatment. Small-diameter plastic pipes form adequate sewers and because of the vacuum present they may be laid at any gradient, even upwards. The remaining household waste waters can normally be discharged to receiving waters without treatment, using a similar sewerage system employing an hydraulic vacuum. The vacuum principle may also be used for discharge of storm waters and for conveying industrial waste waters to treatment plants.

245
SOLUTION FOR STORM SEWER SYSTEM PROBLEM.

L. E. McMahon.
Amer Ass State Highway Officials-Committee on Electronics-Regional Conf on Improved Highway Eng Productivity, Chicago, Ill., pp VII-14-25, April 19-20, 1963.
(through Eng Index, p 1870, 1964).

Descriptors: *Computer programs, *Design, *Rainfall intensity, *Rainfall-runoff relationships.
Identifiers: *Storm sewers.

Program was developed at Michigan State Highway Dept for solution of storm sewer system problem created by accelerated highway program. Program is written for processing on 20 K IBM 1620 computer equipped with floating point and indirect addressing features. Solution is based on use of "Rational Method for Design of Storm Sewer Systems", Manning formula and use of rainfall intensity and runoff curves developed to meet Michigan's needs.

246
STORM SEWER TUNNELING IN SANDSTONE.

K. K. McRae.
Public Works, Vol 98, No 2, pp 110-11, Feb. 1967.
(through Eng Index, p 2474, 1967).

Descriptors: *Tunnel construction.
Identifiers: *Storm sewers.

Features of tunneling in St. Paul and Minneapolis, Minn. are discussed. Normal stratigraphic sequence from surface down is-glacial drift (mixed silts, sands, clays, shales and boulders), Platteville Limestone, Glenwood Shale and St. Peter Sandstone. Procedure in advancing tunnel was to direct h-p water at face to erode sandstone into sand slurry. Mining water was obtained from dewatering wells and carried to machine in 8 in. pipe, passed through jet pumps, and directed at face through 1/4-in. diam nozzles mounted on hand lances. Cutting pressure developed at pump was 400 psi. For tunnel lining modified type 3 grade Y concrete is used by concrete pumping machine. Overall footage normally averages from 30 to 50 ft in 8-hr shift.

247
STORM SEWER ENDS MAN-MADE FLOODS.

Alfred R. Pagan.
Amer City, Vol 78, p 87, Jan 1963.

Descriptors: *Storm runoff, Surface drainage.
Identifiers: *Storm sewers, *Urban drainage.

The Borough of Palisades Park, N.J., part of the metropolitan New York complex, had a storm drainage problem. How this problem was solved is described.

248
ARE PROTECTED STORM WATER OUTLETS DANGEROUS TO STREAMS?

W. Passavant.
Gesundh Ing, Vol 75, pp 362-3, 1954.

Descriptors: *Water pollution, Storm runoff, *Outlets, Equipment.
Identifiers: *Storm sewers.

The author gives a brief survey of possible methods for reducing pollution by storm water with special reference to the use of centrifugal screens.

249
STORM SEWER SYSTEMS.
Amer Public Works Assoc Res Foundation.
Herbert G. Poertner.
State and Local Public Facility Needs and Financing, Subcommittee on Economic Prog of the Joint Economic Committee - Congress of the US - Vol I, Public Facility Needs, pp 152-174, Dec 1966. 5 fig, 7 tab.

Descriptors: *Design.
Identifiers: *Storm sewers.

A broad study of storm sewer systems is presented. Characteristics, functions, and basic principles are discussed as well as standards of performance and design. The existing capital plant of storm sewers is described. History, distribution, age and ownership are all discussed and statistics are given. Costs, charges and benefits are described. Trends of capital outlay are discussed. Graphs show annual U.S. sewer pipe requirements for various size pipes. Expenditures by private land developers and public agencies are discussed. Sources of financing are outlined. Needs, prospective capital outlays and sources of funds for 1966-67 are discussed.

250
CALCULATION OF RETENTION TANKS IN STORM-WATER SEWERS.

R. Randolf.
Wasserwirtsch - Wassertech, Vol 9, p 148, 1959.

Descriptors: *Storm runoff, Drainage systems.
Identifiers: *Capacity, *Storage tanks, *Calculations.

The author discusses, with practical examples, the calculation of size of retention tanks on storm-water drainage systems.

251
SPLIT LEVEL DESIGN FOR SEWER SEPARATION.

W. G. Ridge.
Public Works, Vol 97, No 11, p 97, Nov 1966.
(through Eng Index, p 2473, 1967).

Descriptors: *Sewers, *Construction, *Tunnels, *Storm runoff.
Identifiers: *Storm sewers, *Sewer separation.

Installation of sanitary sewers at invert of previously used combined sewer system is described. Four cuts were made into 102-in. sewer and 10 to 12-ft long corrugated steel pipe sections were lowered with setting into position by fork-lift truck working inside sewer. Sanitary sewer was of eliptical section. After placement, corrugated pipe was grouted with concrete to provide smooth flow for storm water. Corrugated sanitary sewage pipe has been handling average flow of 25 million gpd, and storm water capacity in modified tunnel is 500 cfs.

252
HIGHWAY DRAINAGE AND EROSION CONTROL.

J. L. Sanborn.
Purdue Univ - Eng Ext Ser - Eng Bull 113, pp 68-73, 1963.
(through Eng Index, p 1743, 1964).

Descriptors: *Highways, *Drainage systems, Surface runoff, *Outlets.
Identifiers: *Storm sewers.

Principles involved in controlling erosion and providing proper surface drainage are reviewed. How to build adequate transverse slopes and longitudinal grades on roadways, collecting ditches along roadside, and stable outlets to established water courses is discussed.

253
THE APPLICATION OF STORAGE CAPACITY TO THE DESIGN OF SEWERS.

E. J. Sarginson.
Surv, Vol 119, p 215, 1960.

Descriptors: *Design, *Hydrographs.
Identifiers: *Storm sewers, *Capacity, Calculations.

The author shows how calculations involving the storage capacity of circular sewers can be applied to reduce the size of the conventional storm-water sewer, dealing particularly with the effect of the shape of the hydrograph of flow into the pipe on the rate of flow out of the pipe. It is suggested that reduction of pipe diameter to less than conventional size should be confined to the lower large parts of a sewerage system.

254
STORM SEWER DESIGN FACTORS.

C. S. Seabrook.
Amer City, Vol 79, p 76, July 1964.

Descriptors: *Design, Discharge (water), Drainage, *Flow measurement, *Rainfall intensity, *Runoff, *Intakes.
Identifiers: *Storm sewers, *Urban drainage.

An approach to the determination of design discharges for storm sewers in Puyallup, Wash. is discussed, wherein the runoff coefficient to be used, and the actual contributing area within the given drainage area is determined by actual flow measurements to a curb inlet, with the resultant flow being related to recorded rainfall intensities. Results of the experiments revealed justification for considering only the street rights of way as the contributing drainage area, and the assignment of a 0.9 runoff coefficient to this area, for purposes of design discharge calculations. Such examination of actual runoff conditions, as opposed to the arbitrary selection of a runoff coefficient times a total contributing drainage area, is reported to have saved the city some 20 percent on a million dollar storm sewer project.

255
FUNDAMENTALS OF SEWER DESIGN.

W. O. Seppa.
Hydrocarbon Process Petrol Refiner, Vol 43, No 10, pp 171-6, Oct 1964.
(through Eng Index, p 2237, 1965).

Descriptors: *Design, Sewers.
Identifiers: *Storm sewers.

Four basic sewer systems used in typical hydrocarbon processing plants are oily water sewer, acid (chemical) sewer, storm water sewer and sanitary sewer. Design and operation of each type are discussed.

256
GROUND WATER CONTROL FOR HIGHWAYS.

T. W. Smith.
Nat Res Counc - Highway Res Board - Res Rec, No 57, pp 35-52, 1964.
(through Eng Index, p 2092, 1965).

Descriptors: *Highways, *Groundwater, *Subsurface drainage, Design, Construction.

Subsurface drainage procedures used in design and construction of highways in California are described. Application, construction, and effectiveness of stripping and blanketing with permeable material, stabilization trenches, horizontal drains, and other specialized measures used for subsurface water controls are discussed. Particular consideration is given to characteristics of permeable material.

257
SIMPLIFIED SEWER DESIGN.

R. B. Steytler.
Public Works, Vol 91, p 102, June 1960.

Descriptors: *Sewers, *Design, Drainage systems, Rainfall intensity.
Identifiers: *Storm sewers, *Capacity, *Calculations, Erie, Pa., *Urban drainage.

This article points out the necessity for revamping and extending the sewer system of the City of Erie, Pennsylvania, due to the growth in population and expansion of the area served by the system in recent years. The earlier designing did not take into consideration the future potential of the drainage areas, a situation which is typical in a number of communities. A simplified sewer design method was developed for use in extending and modifying the storm and sanitary sewer systems in the city which, according to the author, has proved effective and time saving both in original design and for checking of the existing system. The method consists of equating area to quantity of both sanitary and storm flow and superimposing the information on any one of a number of sewer design charts available. In this case a diagram based on Kutter's formula ($n = 0.013$) was selected. Basic sewer design principles are discussed together with development and adaptation of this design method. Drainage areas for both sanitary and storm drainage are plotted on the sewer design chart opposite the corresponding quantities of sewer flow. The sanitary portion of the chart was designed strictly on a population basis, with a sufficient safety factor to lead to an over-design. The chart is designed for the minimum size storm sewers considered economically safe in the City of Erie and a different runoff coefficient may be necessary in the application of the method in other areas. A design chart (based on Kutter's formula $n = 0.013$) is presented and the use of this method is illustrated and the procedures followed in applying the method are described. The chart is based on an average condition in Erie but its use in another area would possibly require an entirely different set of figures due to local design considerations. It is pointed out that, while the calculations and intentions of the sewer design chart is to over-design, it is still necessary for the final design to be checked to determine if the area under consideration is similar to that for which the chart was developed and includes all the potential drainage basin. A chart showing a rainfall intensity curve used for storm sewer design in Erie is also presented.

258

PROGRESS TO DATE AND CURRENT WORKS AT GLENROTHES NEW TOWN.

G. A. Sutherland.

Inst Munic Eng J, Vol 94, pp 325-9, Oct 1967.

Descriptors: *Surface drainage, *Storm drainage, Storms, Flood control, *Design, *Sewers, Runoff, *Discharge (water), *Hydrographs, *Construction costs, *Rainfall intensity.

Identifiers: *Storm sewers, *Urban drainage.

Glenrothes, the second new town in Scotland, designated under the New Towns Act of 1946, was designed to contain an area of 5,730 acres and a target population of 32,000. Shopping, educational, and housing provisions are briefly discussed. The complete system of foul and surface water catchments is gravity operated and it has not been necessary to resort to either pumping or tunneling to maintain the gravity system. Two catchments, one draining the northern portion of the town (3,550 acres) and one draining the southern portion (2,180 acres) are described. A once in ten-year storm which should produce bank-full conditions and flooding has been provided for by twenty acres of balancing pond capacity based on an average water depth of three ft. This provision is estimated to cost £60,000. Design considerations are discussed for foulwater sewers and for surface water sewers. Foulwater runoff was based on a future water consumption of 50 gal/head/day. Trunk and development sewers within housing areas were designed for a peak flow of 6 D.W.F. A discharge rate of 7 cumins/acre was calculated for 1/3 of the area; the remaining 2/3 discharging at the rate of 1 cumin/acre. The trunk surface water sewer was designed by the Road Research Laboratory's Unit Hydrograph method for a once per year storm. This method showed an 3% saving in cost over the previously used design method (M.O.H. rainfall intensity curve). Subsidiary sewers were designed using the rational method and Bilham's once per year storm. Continuing rainfall observation is expected to establish a rainfall intensity curve for the area.

259
SHORTCOMINGS AND POTENTIAL OF ZONING.
Natl Assoc of Home Builders, Washington, D.C.
Lee Anthony Syracuse.
ASCE Proc, J Urban Planning Devel Div, Vol 93, No UP4, pp 53-62,
Dec 1967.

Descriptors: *Highways, *Storm drains, Surface runoff.
Identifiers: *Storm sewers.

Broad aspects of zoning are discussed. A brief discussion of storm sewers in cul-de-sac easement lanes is included. Inverted crown roads or one-sided sewer installation with the street slightly slanted toward the sewer can be used.

260
EMPIRICAL MODEL FOR PREDICTING DRAINAGE SYSTEM PERFORMANCE.

P. A. Taylor, and D. G. Watts.
Amer Soc Agr Eng, Trans, Vol 10, No 6, pp 723-6, 729, Nov-Dec 1967.
(through Eng Index, p 51, July 1968).

Descriptors: *Drainage systems, *Design, Sewers, *Computer programs.

Effect of springtime weather patterns, soil physical factors, and drainage system geometry on optimum design drainage coefficient for sizing mains and submains was studied at Oregon Agricultural Experiment Station. Study of Amity series is reported. Development of computer programs for water table simulation is discussed.

261
STORM DRAINAGE PROBLEMS AND SOLUTIONS.

A. L. Tholin.
Public Works, Vol 92, No 8, p 172, 1961.

Descriptors: *Planning, Cities, *Storm drainage.

In a paper presented at a conference on environmental engineering and metropolitan planning the author outlined the problems encountered concerning the estimation and disposal of storm drainage and discussed how these problems could be solved.

262
FUNCTION AND ORGANIZATION OF HIGHWAY DRAINAGE SECTIONS.

F. W. Thorstenson.
ASCE Proc, J Highway Div, Vol 91, No HW 1, paper 4207, pp 49-54, Jan 1965.
(through Eng Index, p 2093, 1965).

Descriptors: *Highways, *Drainage, *Surface runoff.
Identifiers: *Storm sewers.

Basic function of highway drainage section, as related to design of culverts, bridge waterway openings, storm sewers, and erosion control facilities, is described. Services pertaining to drainage matters that normally confront highway department organizational structure is suggested. Procedures for conducting drainage activities are described.

263
DESIGN OF STORM SEWER SYSTEMS.

L. H. Watkins.
Chartered Munic Eng, Vol 90, No 11, pp 337-41, Nov 1963.
(through Eng Index, p 1870, 1964).

Descriptors: *Design, *Rainfall-runoff relationships, *Computer programs.
Identifiers: *Storm sewers, *Urban drainage.

Research into relation between rate of rainfall and rate of runoff from urban areas is discussed. New method of calculating sewer sizes developed as result of research is described. Programs for electronic digital computer have been evolved to enable method to be used simply and economically for designing new sewer systems and examining and redesigning existing systems.

264

EFFECT OF USING CONTINUALLY SUBMERGED DRAINS ON DRAIN SPACINGS.

J. Wesserling.
J Hydrol, Vol 2, No 1, pp 33-43, 1964.
(through Eng Index, p 460, 1964).

Descriptors: *Storm drains, *Plastic pipes, Construction, Drainage systems.

Solution of flow problem given by Kirkham (1958) has been worked out for submerged drains. Some calculation examples show that under certain favorable conditions considerable increase of drain spacing can be obtained by using deep, submerged drains. Installing of such drainage systems is possible when using plastic pipes. Carrying out drainage works under wet conditions, as will be often necessary, may in some soils impair structural stability of soil surrounding pipes. It should be investigated in what measure this will be the case when using modern laying methods.

265

DRAIN THAT GREW AND GREW.

G. B. Wilkes, and J. R. Beilby.
Can Munic Util, Vol 103, No 4, pp 15-17, April 1965.
(through Eng Index, p 2238, 1965).

Descriptors: *Storm drains, Outlets, *Velocity, *Spillways.
Identifiers: *Storm sewers.

Features of Wilson Heights-Spadina Expressway storm trunk drain, Toronto, Ont., are described. Length of line selected is approximately 13,000 ft, and difference in elevation between invert of sewer at interchange and Don River outfall is approximately 136 ft. Grade of sewer was chosen at 0.45 percent to keep maximum velocities below erosion velocity. With this grade, sewer was constructed from 34 to 80 ft below ground level until it interrupted gully which ran back in from river. Feasibility of carrying water in open channel via gully with small spillways to dissipate energy was ascertained.

266

## SOIL AND WATER PROBLEMS ON BUILDING SITES.

D. A. Williams.
Public Works, Jan 1961.

Descriptors: *Land use, *Construction, *Water pollution, Outlets, Recreation facilities, *Stilling basins.
Identifiers: *Storm sewers.

Areas under construction such as new suburbs where all vegetation is stripped off and natural water courses are disturbed with streets, buildings, etc. are creating erosion problems with siltation of rivers and lakes. Even areas designed with storm sewers experience this problem because of the time lapse to get cover, lawn, etc. to grow. A study was made at a 8,200 acre undeveloped area outside Memphis, Tennessee, that is scheduled for development and the engineers recommended that 44 detention basins be built at a cost of $1,400,000 instead of storm sewers. Basins to be designed to retain 60 percent of a 6-hour rainfall of 100-yr occurrence. The outlets would empty the basins in 24 hours. The larger detention sites could become green acres for parks and recreational use. Smaller basins or dry basins could be landscaped in with development.

267

## GRAPHIC STORM SEWER DESIGN.

G. E. Zoellner.
Water Sewage Works, Vol 109, p 447, Dec 1962.

Descriptors: *Design, Storm runoff, Overflow, *Rainfall intensity, Weirs.
Identifiers: Calculations, *Storm sewers, Storage tanks.

The exorbitant costs of storm sewer systems require the decision as to the degree of protection to be provided against property damage, nuisance, and inconvenience from surcharged sewers. The exact determination of the permissible frequency is not possible with the presently used methods, e.g., empirical formula and Rational Method. The graphic Method, as used in Germany for 50 years, makes it possible to determine exactly the runoff for any frequency of surcharging, and this runoff is based on the most critical rainfall for each sewer stretch with regard to the relationship of rainfall intensity to rainfall duration. The Graphic Method permits analysis of storm water reservoirs and calculation of excess flows that are diverted over a weir as the rate of flow with respect to the time is given. The illustrated example shows that the storm sewer system designed with the Rational Method based on a 5-year storm frequency and 15 min. time of concentration will actually surcharge once a year.

# Section VII

# STORMWATER - QUANTITY, QUALITY AND POLLUTION

137-A

268

### SOURCES OF NITROGEN AND PHOSPHORUS IN WATER SUPPLIES. TASK GROUP REPORT.

Amer Water Works Ass J, Vol 59, pp 344-366, 1967.
(through Water Pollut Abstr, Vol 41, No 3, p 106, Mar 1968).

Descriptors: Runoff, *Nutrients, Nitrogen, Phosphorus, *Water supply.
Identifiers: *Urban drainage.

In this second part of Task Group 2610P of the American Water Works Association the sources from which nitrogen and phosphorus may enter water supplies are reviewed; a bibliography of 63 references is appended. Sources of these nutrients include sewage, synthetic detergents, industrial wastes, compounds used in water treatment, run-off from agricultural and urban areas, wastes from farm animals and wildfowl, rainfall and dustfall, and nitrogen fixation. Some figures showing increases in nutrient content of various rivers and lakes in U.S.A. are quoted. From the available data, an attempt has been made to estimate the relative significance of the various sources of nitrogen and phosphorus, and the results are tabulated, showing that agricultural run-off is the greatest single contributor of nitrogen and phosphorus to water supplies. The possibility of controlling the amounts of nutrients contributed by various sources is considered briefly.

269

### CALIFORNIA HIGH WATER, 1965-1966.

Calif, Dep Water Resources, Bull 66-69, Aug 1967. 61 p.
(through Eng. Index, p 90, Mar 1968).

Descriptors: Rainfall-runoff relationships, Precipitation intensity, *Storm runoff, Storms.
Identifiers: California.

Report provides information on meteorology, rainfall-runoff, and damages resulting from major storms of 1965-66 water year. It describes general weather patterns preceding and during storm periods, including precipitation characteristics and discusses resulting runoff in seven hydrograph areas of state. It presents information on flooded areas and damages; two storms during Nov 1965 recorded total of 30 in. of precipitation and one-day maximum of 12.4 in. at station in Santa Ana River Basin.

270
SEWERAGE MANUAL AND DIRECTORY, 1963.

Can Munic Util. 144 pp.
(through Water Pollut Abstr, Vol 37, No 4, p 124, April 1964).

Descriptors: *Surveys, *Storm runoff, *Water pollution, Sewage treatment.
Identifiers: *Canada.

This publication contains a Manual Section (pp. 17-60, 135-138, and 140-141), giving information on various aspects of sewage treatment and disposal; a pictorial review of equipment (pp. 62-89); and a statistical section, giving details of the sewerage systems and sewage works in each province of Canada (pp. 91-113). The Manual Section includes articles on air utilization in sewage works (Dutton, C. S.), including aerated detritus tanks, aerated channels, and types of equipment for aeration in the activated-sludge process; "package" and "compact" sewage-treatment plants (Grunwell, H.), with illustrated descriptions of representative plants, namely the "Accelo-Biox", "Rated-Aeration", "Sparjair", "Oxigest", and "Septi-Robic" units, all of which are based on an extended-aeration process, and the "Simplex" Corner Pocket Plant (based on the standard activated-sludge process). "Clarigester" (providing primary treatment and digestion), and "Oxigritter" (primary treatment); elutriation of digested sludge (Scott, G. T. G.); problems caused by synthetic detergents (Berry, A. E.), including data on the concentrations of these materials in sewage, sewage-works effluents, river water, storm water, well water and laundries waste waters in Ontario, and the remedial measures taken; pumping in sewage systems (MacKenzie, J. A., and Tattersall, J. K.); and instrumentation, control and automation for sewage works (Simmons, R. A. G.).

271
CLEAN UP OF LAKE MICHIGAN.

Effluent Water Treat J, Vol 8, No 5, p 255, May 1968.

Descriptors: *Water pollution control.
Identifiers: *Combined sewers, *Lake Michigan, Storm sewers, *Sewer separation, *Urban drainage.

Pollution control authorities in the four states bordering Lake Michigan and the Federal Government have signed an agreement with broad powers to correct pollution in that lake. According to this agreement, storm and sanitary sewers are to be separated in new developments and in connection with urban reconstruction projects, unless pollution can by controlled by other techniques. Pollution from existing combination storm and sanitary sewers is to be controlled by July 1977 by separation of sewage before it reaches the waterways.

272
POLLUTION OF THE RIVER MERSEY.

Effluent Water Treat J , Vol 3, pp 217-22, April 1963.

Descriptors: *Storm runoff, *Overflow, Cities, *Water pollution, Bioindicators.
Identifiers: *Combined sewers, *River Mersey, Great Britain.

The chief source of pollution in the River Mersey is from large discharges of trade effluents. The discharge of such wastes into public sewage treatment works would improve the condition of the river substantially. The desirability of treating trade wastes in sewage treatment plants indicates the advantage of centralization of sewage disposal works. Another major source of pollution in urban areas in the premature operation of storm sewage overflows. This frequently happens in dry weather when streams are at low flow. The Mersey River Board has recommended that, where practicable, the overflows would not operate until at least 8 times dry weather flow has been reached. The significance of pollution is evidenced by typhoid, and Salmonella infections directly from polluted water or indirectly from food contaminated by it.

273

## RECLAIMED WATER WILL HELP FILL LAKES.

Public Works, Vol 96, No 3, pp 82-83, 1965.
(through Water Pollut Abstr, Vol 39, No 9, p 291, Sept 1966).

Descriptors: *Storm runoff, Drainage, Tunnels, Design flow, *Water reuse.
Identifiers: Combined sewers, Minneapolis, Minn.

Details are given of a proposal to use storm water and water discharged from air-conditioning plants to maintain the levels in a chain of recreational lakes at Minneapolis, Minn., during the summer months. By constructing a control dam in the lower portion of the existing system of drainage tunnels, 2.6 mil. gal. of water can be impounded. The dam will be fitted with a sluice gate which will permit periodic flushing of the system, and will open automatically during heavy rainfall. The air-conditioning water is of good quality, and precautions will be taken to avoid interconnections between the tunnels and the city's combined sewerage system. It is estimated that, in spite of variations in flow, the design flow of 22 $ft^3$ per sec can be maintained during most of the 100-day period when it is intended to divert water to the lakes.

274

## PROGRESS AT COLCHESTER SEWAGE-TREATMENT WORKS.

Surv Munic City Eng, Vol 127, No 3840, pp 28-29, 1966.
(through Water Pollut Abstr, Vol 40, No 3, p 123, March 1967).

Descriptors: Storm runoff.
Identifiers: *Storage tanks.

Progress on the construction of a new high-level inlet works and on the reconstruction of 2 high-level storm-water tanks, at the Haven sewage works, Colchester, is reviewed and illustrated.

275
WHAT TO DO ABOUT POLLUTION FROM STORM SEWAGE OVERFLOWS.

Wastes Eng. Vol 33, 1962.

Descriptors: *Storm runoff, *Overflow, Outlets, *Chlorination, *Ozone, Design.
Identifiers: *Storm sewers, *Urban drainage, *New York, N.Y.

In a symposium on the treatment of storm sewage overflows presented by the Sanitary Engineering Division, Metropolitan Section, American Society of Civil Engineers, the subjects discussed were frequency and composition of storm-sewage overflows; the effect of storm-water outfalls on waters around New York City; techniques of analyzing and classifying harbor water; sewage and storm-water chlorination; treatment of storm-sewage overflows with ozone; design of facilities for chlorinating storm water; and design and operation of sewerage systems to minimize pollution.

276
REPORTS ON THE PROGRESS OF APPLIED CHEMISTRY, VOL XLVIII.

Society of Chemical Industry, London, 1963. 800 pp.
(through Water Pollut Abstr, Vol 38, No 4, p 126, April 1965).

Descriptors: *Water pollution control, *Legislation, *Storm runoff, Bioindicators.
Identifiers: *Bacteriological sampling.

Progress in the various branches of applied chemistry is reviewed, with a comprehensive list of references appended to each chapter. The following are among the subjects considered (1). Sewage, trade wastes and river pollution. McNicholas, J. (pp. 322-333). This review covers legislation to control pollution of surface waters and beaches, and studies on river pollution; effect of polluting materials on fish; storm sewage; percolating filters; activated-sludge process; sludge treatment; effects of synthetic detergents; treatment of trade waste waters; and instruments for the control and monitoring of sewage-treatment processes. (2). Biodegradability of detergents. Dicker, D. W. G. (pp. 334-342). Current progress in the development of "biologically-soft" anionic detergent materials and the control of "hard" materials is outlined, followed by a review of work on the measurement of biological degradability and its relation to molecular structure; studies on non-ionic detergents since their relative contribution to pollution will increase as biologically-soft anionic detergents come into general use; and studies on the toxicity of surface-active agents and the removal of alkylbenzenesulphonates from waste water. (3). Microbiology of water, sewage and industrial effluents. Allen, L. A. (pp. 532-541). This chapter covers the microbiology of water, especially sewage-polluted water, and of waste-treatment processes, particularly the various modifications of the activated-sludge process and the treatment of carbonization, cyanide, cellulose-manufacture and other trade waste waters. (4). Sampling for bacteriological examination. Gibbs, B. M. (pp. 541-549). Included in this review are sampling devices and techniques for the microbiological examination of water and mud. Other chapters of the report contain information on the disinfection of water by chlorination (p.566) or ozonation (p. 602), demineralization of sea water using soluble phthalocyanine dyes to increase the rate of solar evaporation (p. 54), and the use of plastic pipes for drinking water (p. 622).

277
WATER POLLUTION RESEARCH, 1965.
Ministry of Technology.

H M Stationery Office, London, 1966. 224 pp, 4 plates.
(through Water Pollut Abstr, Vol 39, No 10, p 340, Oct. 1966).

Descriptors: *Storm runoff, Sewage treatment.
Identifiers: Great Britain.

This report contains information on work carried out at the Water Pollution Research Laboratory during 1965, including investigations on the activated-sludge process and biological filtration; biological decomposition of synthetic detergents; role of protozoa in biological treatment processes; ecology of invertebrates in filters; sedimentation of sewage and humus; factors affecting digestion and dewatering of sludge; volume and composition of storm sewage; treatment of humus-tank effluent in pebble-bed clarifiers; recovery of water from sewage effluents; treatment and disposal of various types of trade waste water; effects of pollution on fish; oxygen balance in streams; control of water weeds and midges; growth of sewage fungus in streams; dispersion of sewage from sea outfalls; and development of analytical methods and instruments. A list of papers published during the year is appended.

278
WATER POLLUTION RESEARCH, 1964.
Ministry of Technology.

H. M. Stationery Office, London, 1965. 182 pp.

Descriptors: Sedimentation; *Storm runoff; *Biochemical oxygen demand; *Chemical analysis; Flow measurement.
Identifiers: *Suspended solids; *Great Britain.

This report contains the results of investigations on the following subjects: 1) aerobic biological treatment of sewage and industrial wastes; 2) sedimentation processes; 3) sludge treatment; and 4) sewage. The data obtained on the flow and composition of storm sewage at Brighouse, Yorkshire have been analyzed. Although the B.O.D. and concentration of ammoniacal nitrogen in storm sewage were lower than the dry-weather values, the concentration of suspended solids was always much higher. In general, the B.O.D., permanganate value, and ammonia content of the storm sewage discharged in the first 15 minutes were about twice as great as that discharged after the first 30-40 minutes; the reduction in suspended solids content was much less marked.

279
ANNUAL REPORTS OF THE CUMBERLAND RIVER BOARD, THE NORTHUMBERLAND AND TYNESIDE RIVER BOARD, AND THE WEAR AND TEES RIVER BOARD FOR THE YEAR ENDED 31ST MARCH, 1964.
Cumberland River Board, the Northumberland and Tyneside River Board, and the Wear and Tees River Board.

58 pp, 2 graphs; 58 pp, 4 plates, 1 map; and 90 pp, 15 graphs, 8 tables, and 3 plates.
(through Water Pollut Abstr, Vol 39, No 5, p 147, May 1966).

Descriptors: *Storm runoff, *Water pollution, *Waste dilution, Standards, *Overflow.

These reports contain information on water resources, fisheries, and prevention of pollution, including the quality of water and sources of pollution in individual rivers; standards for effluents from sewage works, storm-sewage tanks and overflows, individual properties, farms, and trade premises. In the Wear and Tees area, serious pollution, with obvious pollution by crude sewage, was observed in a small stream following a heavy storm, showing that overflows of storm-sewage are not adequately diluted by the increasing flow of the receiving stream when the stream is small and the storm-sewage overflow setting is low.

280

TWELFTH AND THIRTEENTH ANNUAL REPORTS BEING FOR THE YEARS ENDED 31ST MARCH, 1963 AND 31ST MARCH, 1964.
Lancashire River Road.

102pp, 106pp.
(through Water Pollut Abstr, Vol 38, No 9, pp 318-19, Sept. 1965).

Descriptors: *Storm runoff, *Overflow, *Water pollution.
Identifiers: *Storage tanks *Urban drainage.

These reports contain information on water resources and the prevention of river pollution, both of which were affected by the severe cold weather early in 1963. One of the principal problems in the industrialized parts of the area is the pollution caused by storm sewage overflows, and to alleviate pollution caused by the "first flush" of storm sewage overflows the Board has suggested the provision of holding tanks. An investigation was begun into the factors causing growth of Sphaerotilus natans in a river below the outfall from a paper mill where suspended solids content and BOD of the effluent are very low. Other special investigations included studies on the Wyre estuary to determine the composition and rate of discharge of effluents which could be considered unlikely to harm migratory fish. The criteria used in assessing the degree of pollution of a river or stream are summarized.

281

TWELFTH AND THIRTEENTH STATUTORY ANNUAL REPORTS, YEARS ENDED 31ST, MARCH, 1963 AND 31ST MARCH, 1964.
Trent River Board.

116 pp, 2 maps, 6 plates.
(through Water Pollut Abstr, Vol 38, No 12, p 428, Dec 1965).

Descriptors: *Water pollution, *Storm runoff, *Overflow, Surface runoff.
Identifiers: *Storm sewers, *Suspended solids.

These reports of the Trent River Board contain sections on water resources, fisheries, and prevention of river pollution, including information on water quality (which is interpreted in relation to the discharge of polluting waste waters and the effects of severe cold weather); remedial action; and standards for effluents. Chemical data obtained in river surveys are appended and are correlated with biological characteristics as represented by the Biotic Index. The principal cause of fish mortalities was de-oxygenation of river water due to prolonged ice and snow cover or to the operation of storm-sewage overflows following periods of dry weather; the first flush of water discharged from surface-water sewers after a dry period is also highly polluting and contributes to de-oxygenation. During the first few days of April each year the rivers Tame and Trent carry in suspension large quantities of detached sewage fungus which, under conditions of low flow, settle out with other suspended matter and tend to become black in color; following rainfall and increased flow in the rivers, this material is scoured out into suspended matter and tend to become black in color; following rainfall and increased flow in the rivers, this material is scoured out into suspension and exerts a considerable oxygen demand thus contributing further to the de-oxygenation. The cold winter of 1963 inhibited nitrification at most of the sewage works; this caused increased concentrations of ammonia in the receiving waters at a period when flow was minimal and the frozen surface of the rivers prevented aeration, and is considered to be the cause of elimination of fish in a stretch of the river Soar. Prevention of Pollution By-laws became operative in November 1962.

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## SECOND QUINQUENNIAL ABSTRACT OF STATISTICS RELATING TO RIVER SURVEYS IN THE TRENT WATERSHED COVERING THE FIVE-YEAR PERIOD 1957 to 1961 (with some suppl data for 1962).

Trent River Board, Pollution and Fisheries Dep. 120 p, 1 map.
(through Water Pollut Abstr, Vol 38, No 12, pp 428-9, Dec 1965).

Descriptors: *Storm runoff, *Water pollution, Sewers, Overflow.
Identifiers: *Urban drainage.

Data are tabulated from chemical and biological surveys of rivers in the Trent watershed in the period 1957-1962, and the percentage change in composition between 1951 and 1962 is estimated for various sampling points. The condition of the various stretches of watercourses is indicated on a map using a color-coding scheme. At present, about 80 per cent of the streams in the watershed are reasonably clean and of some use to the community, but there are still about 150 miles of watercourse which are badly polluted. Only 60 per cent of the sewage effluents reach the requirements set by the River Board but the treatment facilities are being improved gradually. Factors contributing to the deterioration of surface waters are discussed, including the delay in constructing waste-treatment facilities for new housing and industrial developments, increasing volumes of effluent and increasing abstractions of water (which increase the ratio of used:natural water in the streams), and increasing volumes of storm run-off for which there is insufficient sewer capacity, especially in older urban sewerage systems which do not provide capacity for six or even three times dry-weather flow. Where it is not practicable to improve conditions in streams by imposing higher standards for effluents and discharges from storm-sewage overflows, it may be necessary to consider "farming the river" to ensure the greatest possible degree of self-purification.

283

REPORT ON POLLUTION FROM OVERFLOWS - THE METROPOLITAN SANITARY DISTRICT OF GREATER CHICAGO.

Black & Veatch, Conslt Engrs, Kansas City, Mo.

Prepared for Great Lakes - Illinois River Basins Project, US Public Health Service - Region V, US Department of Health, Education and Welfare, 1962.

Descriptors: *Overflow, Water pollution, Biochemical oxygen demand, Sewage Treatment, *Storm runoff, Surface Runoff.
Identifiers: *Interceptor Sewers, Sewer separation.

Engineering studies of the Chicago Interceptor Sewer System - including identification of system sections which limit capacity, frequency of overflows, and pollution loads (P.E.) - showed an enormous B.O.D. contribution (75%) from the sewage treatment plants in relation to the overall pollution of the waterway. Construction of additional treatment plants nearer to the source of sewage load, tertiary treatment facilities, and ultimately, complete separation of sanitary sewage from storm water, are suggested. Areas requiring further study include the feasibility of stormwater treatment facilities, the pollutional character of surface runoff and the entire industrial waste problem.

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## PRELIMINARY POLLUTION STUDY UPPER EAST RIVER.

Lockwood, Kessler & Bartlett, Inc.

Report to New York City and New York State Depts of Health.

Descriptors: *Water pollution, Sewage effluent, Sewage treatment, *Overflow, Tracers, *Chlorination, *Storm Runoff.
Identifiers: *Combined sewers, *Storage tanks, New York, N.Y.

Basic analysis of origin of pollution in upper East River indicates that these stem from discharge of unchlorinated effluents of 4 major sewage treatment plants and overflows from 80 combined sewers. Hydrographic studies detailing float studies, dye trails and tidal observations indicate travel of pollution in area. Recommendations for further studies to determine the frequency-quantity relationship of rainy weather overflow of raw sewage and to investigate the effect of Ch and/or storage on rainy weather overflows from combined studies are made.

285

## ELIMINATION OF MARGINAL POLLUTION--JAMAICA BAY.

Greeley and Hansen, Engineers.

Report to Dep of Public Works, New York City.

Descriptors: *Deterioration,*Water quality,*Overflow, Recreation facilities, *Storm runoff, *Water pollution, Sewage treatment, *Chlorination, Sedimentation, *Estuaries.
Identifiers: *Combined sewers, *Storage tanks, *Jamaica Bay, N.Y.

This report demonstrates the general relationship between deterioration of beach water quality after heavy rains from overflows of mingled sewage and storm water. Recommendations for specific area corrections are detailed - mainly attempting to develop a system of separate sewers to replace existing and overloaded combined sewers. Recommendations would localize potential pollution from storm water overflows to seven areas where storm water overflow treatment works are suggested. Overflow treatment to consist of large holding basins to capture the overflow, permit sedimentation and chlorination prior to ultimate discharge to Jamaica Bay or pumping to sewage treatment plants.

286
INVESTIGATION OF POLLUTION OF EASTCHESTER BAY.
Bureau of Sanit Eng, N.Y. City Dep of Health.

Descriptors: *Overflow, *Water pollution.
Identifiers: *Combined sewers, *Bacteriological sampling.

Data presented emphasized that overflow from combined sewers is a major contributor to pollution in area. Bacteriological sampling data is tabulated.

287
ACTIVITIES REPORT, JULY 1, 1964 - JUNE 30, 1965, BASIC AND APPLIED SCIENCES BRANCH, DIVISION OF WATER SUPPLY AND POLLUTION CONTROL.

U S Public Health Serv, HEW, 1965, 58 pp.
(through Water Pollut Abstr, Vol 39, No. 7, p217, July 1966).

Descriptors: *Water pollution control, *Surface runoff, Sewage effluent, *Chemical analysis, Bacteriological sampling, Waste dilution.
Identifiers: *Urban drainage.

This report reviews research carried out from 1964 to 1965 by the Basic and Applied Sciences Branch of the Division of Water Supply and Pollution Control, aimed at determining causes and methods of control of water pollution. Work has included studies on the chemical and microbiological analysis of wastes; the polluting effects of urban and rural run-off; the persistence of organic chemicals in surface waters and their amenability to biological degradation; the effects of pollution on aquatic life and on municipal water use; methods of waste treatment, including advanced treatment of sewage; and control of surface-water quality by dilution and by removal of nutrients from effluents. A list of papers published during the year is appended.

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## POLLUTIONAL EFFECTS OF STORMWATER AND OVERFLOWS FROM COMBINED SEWER SYSTEMS.

Public Health Service Pub No 1246, U S Govt Printing Office, Wash, D C, 1964.

Descriptors: *Storm runoff, *Overflow, *Water pollution control, *Sewage treatment, Sewers, Water pollution, Cities.
Identifiers: *Combined sewers.

The purpose of this report is to examine and assess in a preliminary way existing data on stormwater and combined sewer overflows in regards to characteristics and pollutional effects, and to investigate existing and possible corrective measures for dealing with the problem. The sources of data include more than 50 engineering reports and completed questionnaires regarding sewer systems and/or sewage treatment, reports of detailed studies of water quality data and stormwater separations, and interviews with municipal sanitation representatives. These sources provide information on (a) quantity and quality of combined sewer overflows; (b) effects on streams, water uses, and users; (c) adverse effects, and if any, existing or suggested control measures and their effectiveness; and (d) costs necessary for control.

289

## STORM OVERFLOW PERFORMANCE STUDIES USING CRUDE SEWAGE.

P. Ackers, A. J. Brewer, A. E. Birbeck, et al.
Paper presented at the Symp on Storm Sewage Overflows, May 4, 1967.
Sponsored by the Inst of Civ Eng.

Descriptors: *Overflow, *Storm runoff, Sewage treatment, *Weirs, *Stilling basins, Flow control, *Design, Discharge (water).

Experiments were carried out to: a) determine the difference in composition of storm sewage discharge from an overflow and that passed to treatment; b) compare the performance of the different types of overflow; c) examine the effectiveness of scum boards; and d) measure the changes in flow to treatment with increasing total flow in each structure. The types of overflow tested were: a) a low double side-weir; b) a stilling pond; c) a vortex; and d) a high-level side-weir with a positive flow control. The structures tested were designed to operate under hydraulic conditions as nearly identical as possible. The overflows were designed to spill at a discharge to treatment of 1/10 the maximum discharge and, with the exception of the low side-weir, would limit the flow to treatment to 20% above the first spill discharge. The most practical form seemed to be the round-crested type. Measurements were made of: a) the discharge to treatment at first spill; b) the discharge to treatment and spill at various larger incoming flows; and c) the water levels in the overflow chamber for these discharges. The high side-weir had the best general performance, second was the stilling pond with the scum board 6 in. from the crest, and the vortex overflow was the worst.

290

### THE QUALITY OF STORM WEATHER FLOW.

Gunnar Akerlindh.
Satryck ur Nordisk Hyg Tidskreff, Vol 31, No 1, 1950.

Descriptors: *Storm runoff, *Overflow, *Coliforms, Sewage, *Water Quality, *Biochemical oxygen demand, *Rain water.
Identifiers: *Combined sewers.

The quality of storm-water flow, particularly the surplus discharge from combined sewers, is discussed in order to compute the required regulated flow; that is, the amount of flow to be diverted for disposal. The three elements constituting storm-weather flow--namely sewage, ground water, and rain water, have been considered. Coliform bacteria in samples taken from streets (high runoff coefficients) and parks (low runoff coefficients) were compared. The concentration of organic matter in rain water is comparatively great (B.O.D. 100 to 200 ppm) being nearly as polluted as sewage. In regard to coliform organisms, however, the rain water portion of the storm-weather flow has a density of 100 to 1,000 per ml and, accordingly, is much lower than sewage and has a diluting effect on the sewage. The composition of rain water flow varies greatly and indefinitely. Despite this, it is reasonable to assume a constant composition.

291

### ENVIRONMENTAL FACTORS IN RELATION TO WATER USE AND PROTECTION AGAINST POLLUTION.

B. R. Allanson, M. R. Henzen, and O. J. Coetzee.
Proceedings, Resolutions, and Papers of the Conference on the Problems Associated with the Purification, Discharge and Re-Use of Municipal and Industrial Effluents, Natl. Inst. Water Res., Pretoria, 1964, pp 77-92.

Descriptors: *Drainage, *Chemical analysis, *Water pollution, *Runoff, *Water quality.
Identifiers: Urban drainage, *Bacteriological sampling.

Consideration is given to the conditions on the drainage surface of a catchment area which cause changes in the chemical and bacteriological quality of river water, to factors responsible for the self-purifying capacity of streams and rivers, and to criteria upon which the efficient use of South African rivers should be based. Data are included showing how the physical and chemical quality of surface waters is affected by natural factors (dissolved and suspended substances in rain water, access of ground water, and contact with geological formations), agricultural activities, and run-off from residential and industrial areas.

292

### DISCHARGES FROM SEPARATE STORM SEWERS AND COMBINED SEWERS.

W. J. Benzie and R. J. Courchaine.
Water Pollut Contr Fed J, Vol 38, No 3, p 410, Mar 1966.

Descriptors: Discharge (water), *Coliforms, *Chemical Analysis, Runoff.
Identifiers: *Combined sewers, *Storm sewers, *Bacteriological sampling.

Discharges from a separate storm sewer system showed mean median bacterial counts per 100 ml of 12 X $10^5$, 0.82 X $10^5$, and 1.4 X $10^5$ for total coliforms, fecal coliforms, and fecal streptococci, respectively. Corresponding figures for discharge from a combined system were 94 X $10^5$, 2.7 X $10^5$, and 5.8 X $10^5$. The ratios of fecal coliforms to fecal streptococci in the combined and separate systems were 4.7 and 0.6, respectively, indicating that the bacteria in the combined system are primarily of human origin, whereas those in the separate system are derived from other warm-blooded animals. Phosphates and nitrates in combined system discharges were about 3 to 4 times greater than contents in discharges from separate systems.

293

THE DAY-TO-DAY POLLUTION PROBLEMS OF THE THAMES ESTUARY.

L. C. Betts.
Inst Sewage Purif J Proc, Pt 1, pp 48-63, 1964.
(through Water Pollut Abstr, Vol 38, No 4, p 141, Apr 1965).

Descriptors: *Estuaries, *Storm runoff, Discharge (water),*Water pollution control, Legislation.
Identifiers: *Thames estuary.

The author outlines some of the sources of pollution of the Thames estuary and their effects, including shipping, stormwater discharges, used cooling water, sewage-works, effluents, trade effluents, and miscellaneous sources, and indicates some of the measures being taken to reduce pollution, including legislation and the work of the Port of London Authority.

294

DESIGN CRITERIA FOR INTERCEPTOR SEWERS FOR ST LOUIS.

Erwin E. Bloss.
ASCE Proc, J Sanit Eng Div, Vol 92, No SA4, Proc Paper 4877, pp 7-31, August 1966.

Descriptors: *Design, Pumping, Sewers, *Water pollution control, *Storm runoff, Overflow, *Construction costs.
Identifiers: *Interceptor sewers, *Combined sewers, *Capacity, *St. Louis, Mo.

Preliminary to the sizing of the sewers, pumping stations, and treatment plants of the Metropolitan St. Louis Sewer District's Mississippi River Pollution Abatement Project, it was necessary to adopt a design criterion for the interceptors on the combined sewers. The amount of pollutional load spilled to the river during storm water runoff was computed for interceptors of three different capacities when functioning under rainfall conditions corresponding to those experienced during 1955. Pollution was measured in terms of "equivalent hours of sewage flow." It was found that with interceptors having a capacity of 1.0 times peak sewage flow, 3.1% of the total yearly sewage flow would be spilled during storm water runoff. Furthermore, the efficiency of the overall project after primary treatment would be approximately 0.25% less with interceptor capacity of 1.0 times peak sewage flow than with interceptor capacity of 1.25 times peak sewage flow, whereas the increase in cost of the project, using the larger interceptors would have been on the order of $2,800,000. The smaller size interceptor was adopted.

295

OBSERVATIONS ON THE RECOVERY OF A BRITISH RIVER FROM GROSS ORGANIC POLLUTION.

R. O. Brinkhurst.
Hydrobiol, Vol 25, pp 9-51, 1965.
(through Water Pollut Abstr, Vol 39, No 8, p 283, Aug 1966).

Descriptors: Sampling, Water pollution control, Overflow, Storm runoff, Bioindicators.
Identifiers: Derbyshire, Great Britain.

Until 1957 the lower reaches of the river Derwent, Derbyshire, were heavily polluted with effluents from Derby sewage works and from an industrial plant; in 1957, a new sewage works was put in operation to treat both sewage and the industrial waste water and cooling towers and recirculation systems were installed to control the heated discharges. Since then, several biological surveys of the river above and below the sewage works have been carried out; results are tabulated and discussed. Immediately after the removal of the gross pollution there was a dramatic recovery in the condition of the river, but this was followed by a period of fluctuating conditions and there is now a uniformly poor fauna of tolerant species at all stations in spite of the chemical evidence that the river is cleaner above the sewage works than below it; it is concluded that no further improvement can be expected until upstream sources of pollution (mostly small sewage works and storm-sewage overflows) are improved and the flushing of polluted tributaries is prevented. Particular attention has been paid to the Oligochaeta in the river, and the results confirm that these organisms, when identified to species and estimated quantitatively, can be useful in assessing pollution.

296

[THE DETERGENT CONTENT OF RIVER WATER AS A FUNCTION OF WATER FLOW]. Detergentiengekalt von Fliessgewässern in Abhängigkeit von der Wasserführung (in German).

W. Bucksteeg and N. Wolter.
Water Res, Vol 1, pp 325-333, 1967.

Descriptors: *Storm runoff, Outlets, *Detergents, Water pollution, *Waste dilution.

The content of detergent in river water is lowered as the water flow increases because of the dilution, but the total amount of detergents, or the load, rises. This increase is caused by the discharge of sewage without biological treatment through stormwater outlets and by the reduction of the retention-time in the river during the high flow. Both factors diminish the possibility of biological decay, so that the relationship between water flow and detergent load is a result of more or less complete biodegradation. It is influenced by the temperature and degradability of the detergents. The introduction of soft detergents since October 1964 has caused an important decrease in detergents at low and medium water flows. The advantage of soft detergents is therefore masked by the growth of detergent use in recent years.

297

CHEMICAL AND PHYSICAL COMPARISON OF COMBINED AND SEPARATE SEWER DISCHARGES.

R. J. Burm, D. F. Krawczyk, and G. L. Harlow.
Water Pollut Contr Fed J, Vol 40, No 1, p 112, Jan 1968.

Descriptors: Discharge (water), *Biochemical oxygen demand, Sewers. Identifiers: *Combined sewers, *Storm sewers, *Suspended solids, Ann Arbor, Mich., Detroit, Mich.

A comparative study of separate storm-sewer discharges in Ann Arbor, Mich., with combined discharges in Detroit showed that the BOD in the separate discharges was about 20 percent of that in the combined discharges. Concentrations lessened as discharges progressed. Values for total and volatile suspended solids and for total and volatile settleable solids were higher in the separate system because of greater erosion in hillier terrain. Phosphates were higher in combined flows, but nitrates were lower. Higher concentrations also were found in the combined system for phenols, $NH_3$-N, and organic N. In the separate system, BOD was fairly constant throughout the year, but in the combined system summer BOD's were higher. Both systems showed lower phosphate concentrations in autumn.

298

BACTERIOLOGICAL COMPARISON BETWEEN COMBINED AND SEPARATE SEWER DISCHARGES.

R.J. Burm and R. D. Vaughan.
Water Pollut Contr Fed J, Vol 38, No 3, p 400, Mar 1966.

Descriptors: Discharge (water), Sewers, *Coliforms, *Runoff.
Identifiers: *Combined sewers, *Storm sewers.

Comparison of discharges from combined and separate sewer systems in two Michigan cities showed that total coliform concentrations in runoff carried by separate storm systems are about one tenth of those in combined sewers. Fecal coliform densities in combined systems are about 20 percent of total coliform densities, but are usually a lesser precentage in separate systems. Fecal streptococcus densities in combined systems are only about twice those in separate systems. Ratios of fecal coliforms to fecal streptococci for the systems indicate that fecal coliforms in separate sewer discharges are primarily of non-human origin, and those in combined sewer discharges are of human origin.

299

SELF-PURIFICATION IN MUSSELS FROM THE MEDITERRANEAN-ITS USEFULNESS-ITS ACCOMPLISHMENT-RESULTS OBTAINED.

R. Buttiaux and R. Ferrand.
Symp Comm Int Explor Scient Mer Medit, Monaco, 1964, pp 299-306, 1965.
(through Water Pollut Abstr, Vol 40, No 6, p 279, June 1967).

Descriptors: *Water pollution, *Storm runoff, Outlets, *Overflow, *pathogenic bacteria, Standards, *Shellfish.
Identifiers: *Bacteriological sampling, Toulon, France, Interceptor Sewers.

Mussels cultivated in Lazaret bay, Toulon, France, are subjected to much pollution and have in the past caused serious typhoid epidemics. The bay, which is almost completely enclosed, being connected with the open sea by only two narrow passages, receives waste waters from the dockyard and from warships anchored in the harbour; polluting material is also carried into the bay by run-off, during the heavy storms which are frequent in this region; and although an intercepting sewer, with an outfall outside the bay, has been built to divert a large part of the municipal sewage, the storm-sewage overflows still discharge into the bay itself, and the water and mussels still suffer faecal contamination, as shown by tabulated data. Although bacteriological examination of water in the bay before and after a period of 5 hours' sunshine showed an important reduction in the number of Escherichieae, the bactericida action of sea water is slow, especially in the case of Salmonella, and it is too slow to prevent the penetration of salmonellae into molluses. A plant was therefore set up at Toulon for the self-purification of shellfish in clean sea water and the bacteriological quality of mussels was assessed before and after treatment, on the basis of standards proposed for the content of Escherichia coli and Streptococcus D. Good results were achieved as regards the protection of public health, with no loss in the organoleptic quality of the shellfish.

300

### STORM WATER FLOW SELECTION METHOD ELIMINATES SILT PROBLEM.

G. Chanin.
Water Sewage Works, Vol 102, No 8, pp 300-3, July 1955.

Descriptors: *Storm runoff, *Storm drains, Sewage treatment.
Identifiers: *Suspended solids.

New sewage treatment plant in Oakland, California, had disadvantage that large volumes of storm water with fine sand and silt reached it so that sludge collectors were completely covered; to eliminate this, channel was constructed to by-pass storm waters; requirements for test to determine whether sand and silt are present and whether by-pass gates should be opened.

301

SOURCE AND PERSISTENCE OF NEMATODES IN SURFACE WATERS.

N. Chaudhuri, R. Siddiqi, and R. S. Engelbrecht.
Amer Water Works Ass J, Vol 56, pp 73-88, Jan 1964. 4 fig, 12 ref.
(through Public Health Eng Abstr, Vol 43, p 313, 1963).

Descriptors: *Subsurface drainage, *Surface runoff, *Sewage effluent, *Bioindicators, Sampling, Water pollution.
Identifiers: *Bacteriological sampling, *Urban drainage.

The importance of collecting large volumes of water of composite nature to obtain representative samples is stressed. The 5 μ membrane filters yield a complete recovery of nematodes. Subsurface drainage, surface runoff, and waste treatment effluent are the 3 main sources of namatodes in surface waters, but only the waste effluent carries high concentrations of nematodes. Urban drainage has a higher nematode content than that of rural area. The nematode load of a stream receiving rural drainage appears to be related to the flushing capacity of the runoff and of the stream and to the carrying capacity of the stream. The persistence of nematodes in streams appears to be related to the mean stream temperature, the stream temperature changes, the rate of flow of the stream, and the nature of the nematode population. The pattern of seasonal variation in nematode populations in streams appears to be the same regardless of the source of nematodes. 8 tables.

302

FOCUS ON POLLUTION REDUCTION IN SCOTLAND.

R. W. Covill.
Surv, Vol 130, No 3938, pp 25-6, Nov 25, 1967.
(through Eng Index, p 192, April 1968).

Descriptors: *Water pollution control, *Surface runoff, Drainage, Estuaries.
Identifiers: *Scotland.

Industrial and population growth increased number and density of water discharge points along rivers, locks and estuaries, and similarly volume and strength of such discharges have increased. Industrial effluents include organic, inorganic, radioactive, and pollution resulting from heated effluents. Land drainage comprises silt pollution, surplus irrigation water, surface water runoff and agricultural particles and fertilizers. Responsibility for water resources management should be vested in one organization covering functions of potable and industrial water supply, drainage, and municipal and industrial water treatment and pollution prevention.

303

FIELD STUDIES ON THE FLOW AND COMPOSITION OF STORM SEWAGE.

R.N. Davidson and A.L.H. Gameson.
Paper presented at the Symp on Storm Sewage Overflows, May 4, 1967.
Sponsored by the Inst Civ Eng.

Descriptors: *Overflow, *Storm runoff, *Sampling, *Biochemical oxygen demand, *Water pollution.
Identifiers: *Suspended solids.

Investigations on sewers draining three areas, one in Northamptron, one in Bradford, and one in Bridhouse resulted in data from which several graphs and equations were derived and used to estimate the effect of changes in overflow setting on the frequency duration and volume of discharge from a hypothetical overflow. The overflows at Brighouse and Bradford did not conform to such ideal conditions. Calculations indicated that the flow at which first spill should occur might vary by over 3%. These particular overflows are discussed and the various ways of expressing overflow settings are summarized. An automatic sampler was used at each site for storm sewage. There was a tendency for the strength of sewage to decrease with time during a storm. Variations in average composition of storm sewage with ratio of excess flow to total flow are given. Tables are included of the average maximum values of suspended solids and BOD, the multiples of daily dry weather load discharges from hypothetical overflow at Northampton, and existing overflows at Bradford and Brighouse in a year of average rainfall.

304

### BACTERIAL SURVEY OF STREAMS AND BATHING BEACHES AT CLEVELAND.

J.S. Delos.
Sewage Ind Wastes, Vol 22, No 12, pp 1618-24, Dec. 1950.

Descriptors: *Water pollution, *Recreation facilities, *Storm runoff, *Overflow, *Coliforms, Bioindicators.
Identifiers: Bacteriological sampling, Cleveland, Ohio.

This article is a condensation of the original report submitted to the Commissioner of Sewage Disposal and covers the 1949 survey and a comparison with earlier pre-war studies. The objects of the 1949 survey were: 1) To determine the present level of pollution of the bathing beaches as compared to pre-war level. 2) To determine the effect of storm water overflows on the pollution level. 3) To determine the quality of water flowing in the streams discharging into the lakes. Brief description of testing, areas tested and short tables of data are included. Conclusions reached were that coliform count definitely increased during wet period. For a given period, the number of days of rain has a greater effect than the amount of rain which fell at a particular period.

305

### DESCRIPTION OF A COMMUNITY OF MICRO-ORGANISMS IN PURIFIED SEWAGE MIXED WITH RAIN WATER FROM STORM SEWERS.

T.G.N. Dresscher.
Hydrobiol, Vol 14, 1959.

Descriptors: *Storm runoff, *Sewage effluent, Water pollution, *Chemical analysis.
Identifiers: *Bacteriological sampling, Amsterdam, Holland.

The author gives details of the community of micro-organisms isolated during the period 1953-1958 from a canal to which are discharged storm water and the effluent from the activated sludge plant serving the western part of Amsterdam. Sampling procedures and biological investigations are described and a comprehensive list of organisms isolated during this period is given. The determination of microbiocoenosis, based on the number of micro-organisms present, is discussed. Results of bacteriological and chemical investigations are also given. The Eijkman test carried out at 45°C and the determination of faecal streptococci showed a decrease in faecal pollution from 1953 to 1957, but pollution increased again in 1958. The average chemical results also showed that pollution was least in 1956 and 1957, and this coincided with a reduction in the number of Eugleno-phyceae and some other organisms.

306

POLLUTION CONTROL MEASURES FOR STORMWATERS AND COMBINED SEWER OVERFLOWS.

D.D. Dunbar and J.G.F. Henry.
Water Pollut Contr Fed J, Vol 38, No 1, p 9, Jan 1966.

Descriptors: *Water pollution control, *Storm runoff, *Overflow, *Chlorination.
Identifiers: *Combined sewers, *Storm Sewers, *Interceptor sewers, Capacity.

Two primary sources of water pollution other than domestic and industrial wastewaters are the discharges from combined sewer overflows and from separate storm sewer systems. Such overflows can contribute objectionable amounts of pollution to receiving waters. Interceptor and wastewater treatment plant capacity in relation to average dry-weather flow shows that the overall efficiency of raw sewage collection is not improved greatly once such capacity reaches 3 x dry-weather flow. Partial separation of stormwater by collecting street runoff in a collection system independent of an existing combined system markedly increases pollution control efficiency of the existing system; this method is about 40 percent as costly as total separation. Volumetric storage sufficient for a storm of 1.2 in/6 hr (30.5 mm/6 hr) can reduce stormwater escaping treatment from 85 to 40 percent. Chlorination of stormwater runoff or of mixtures of stormwater and raw sewage can reduce effectively bacterial concentrations.

307
POLLUTION CONTROL MEASURES FOR STORM WATERS AND COMBINED SEWER OVERFLOWS.

D. D. Dunbar and J.C.F. Henry.
Can Mun Utilities (Sewerage Manual & Directory) pp 12-20, 1964.
31 ref.
(through Eng Index, pp 2625-6, 1965).

Descriptors: *Water pollution control, *Storm runoff, *Overflow.
Identifiers: *Combined sewers, *Storm sewers.

Relative importance of other sources of pollution, such as mixtures of storm water runoff and raw sewage being discharged from combined sewer systems, as well as pollutional capabilities of storm water being discharged from separate sewer systems are assessed, and merits of various control measures examined. Investigations made to study extent of pollution originating in combined and in separate storm sewer overflows are reviewed.

308
OPERATING CHARACTERISTICS OF BACTERIAL WATER QUALITY STANDARDS.
Walter Reed Army Inst of Research, Washington, D. C.
D. W. Duttweiler.
Amer Water Works Ass J, Vol 58, No 6, pp 742-50, June 1966.

Descriptors: Design, *Water quality, *Bioindicators, *Coliforms.
Identifiers: *Bacteriological Sampling, *Calculations.

Operating characteristics provide a basis for rational design of water quality surveillance programs. In this paper operating characteristic curves of the USPHS bacteriologic quality standards are derived for both the membrane filter method and the most probable number method. These curves indicate the probability that water of a certain coliform bacteria density will be acceptable. The importance of volume and number of monthly samples in determining the risks of unknowingly accepting waters having high coliform densities is discussed. Under present USPHS standards, the probability of rejecting water having a coliform density of 1 per 100 ml. is relatively constant and less than 0.01 for all membrane filter method and most probable number method day-to-day samples. It is suggested that greatly improved drinking water quality control be obtained by examining a minimum of 8 monthly 200-ml. samples by the membrane filter method for continuous surveillance. Operating characteristic curves are shown for monthly control periods for both the membrane filter method and the most probable number method.

309

COLIFORM AFTERGROWTH IN CHLORINATED STORM OVERFLOWS.

R. Eliassen.
ASCE Proc, J Sanit Eng Div, Vol 94, No SA2, paper 5913, pp 371-80, Apr 1968.
(through Eng Index, p 244, June 1968).

Descriptors: *Coliforms, *Storm runoff, *Overflow, *Chlorination, Estuaries.
Identifiers: *Combined sewers, Bacteriological sampling, Dilution.

Laboratory tests were conducted on possible bacteriological effects of combined sewer storm overflows into a tidal estuary. Overflow mixture was diluted with 3 to 25 volumes of estuarine waters to represent dilutions expected under average storm conditions. Bacterial growths were observed in raw overflow and at various dilutions, using 3-liter flasks at 68 F, with incubation periods up to 120 hr. Most probable number values of coliforms were determined after fixed time intervals.

310

THE USE OF LAKES IN CONNECTION WITH SEWAGE DISPOSAL.

L. B. Escritt.
Water Waste Treat J, Vol 7, 1959.

Descriptors: *Surface runoff, *Storm runoff, Outlets, *Flow control, *Lakes, Sewage treatment.
Identifiers: *Capacity, Great Britain.

The author discusses the discharge of partially-treated sewage and of storm water to lakes. Experiences in various countries are quoted, and it is concluded that, with reasonable precautions, lakes could be used in England for the storage of surface run-off without causing nuisance. The design and installation of a module to regulate the outflow from the storage lake to a stream is discussed, and a method and formulae are given for calculating the required storage capacity of a lake in terms of the frequency of storm and rate of outflow from storage.

311

RIVER POLLUTION BY STORM OVERFLOWS. AN ATTEMPT AT RATIONALIZATION.

H. C. Gatehouse.
Surv Munic City Eng, Vol 123, No. 3754, pp 33-34, 37-39, 1964.
(through Water Pollut Abstr, Vol 39, No 1, p 15, Jan 1966).

Descriptors: *Water pollution, *Storm runoff, *Overflow, Water pollution control, Discharge (water).
Identifiers: *Combined sewers.

The author criticizes the interim report of the Technical Committee on Storm Overflows and points out various unsatisfactory aspects of the measures recommended for the control of pollution by storm-sewage overflows from combined sewers. He stresses the dangers to health of such pollution, and indicates steps that should be taken to eliminate discharges of untreated storm sewage.

312

STORM-WATER INVESTIGATIONS AT NORTHAMPTON.

A.L.H. Gameson and R. N. Davidson.
Inst Sewage Purif J, Pt 2, 1963.

Descriptors: *Flow measurement, *Biochemical oxygen demand, *Storm runoff, Water pollution, *Overflow, Sewage effluent, Sewage treatment.
Identifiers: *Suspended solids, *Storage tanks, *Capacity.

Tabulated and graphical results are given of studies carried out at Northampton over a period of 2 years on the flow and composition of sewage in a main sewer, with no overflows, particularly during wet weather. It was found that the strength of the storm sewage entering the system, as judged by the B.O.D., was less at high flows, decreased with time since the start of the storm, and increased with length of time since the previous storm. The storm sewage contained a higher concentration of suspended solids than did crude sewage, the greatest concentration of solids being associated with the first flush of storm sewage and this maximum value was greatest when the storm had been preceded by several days of dry weather. The polluting effect of the first flush of storm sewage is attributed to the scouring out of grit and organic solids deposited in the system during dry weather. It was estimated that, had the system been provided with a storm-water overflow, raising the setting of the overflow by one times dry-weather flow would have roughly the same proportional effect throughout the range from 3 to 30 times dry-weather flow, and no substantial reduction in the amount of polluting matter discharged would be achieved by a small change in the setting. However, the provision of storage capacity equivalent to 2-hour dry-weather flow at the overflow would reduce the B.O.D. load discharged from an overflow set at 6 times dry-weather flow by about 40 per cent, and trebling the storage capacity would reduce the load by a further 20 per cent of the initial value, equivalent to raising the overflow setting to 11 times dry-weather flow. The average B.O.D. load discharged per year from an overflow set at 6 times dry-weather flow would be nearly as great as the B.O.D. load discharged as sewage-works effluent during the same period if the whole flow to treatment were discharged as effluent with a B.O.D. of 20 ppm and the suspended solids discharged would be equivalent to 3 times the load in a sewage effluent containing 30 ppm solids. It is stressed that the results of this investigation cannot be applied to other sewerage systems until comparable data are available for other sites.

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### THE FLOW IN A STREAM AS A MEASURE OF THE DEGREE OF DILUTION OF STORM-WATER DISCHARGES.

R. Gaul.
Gesundh Ing, Vol 73, 404, 1952.

Descriptors: *Storm runoff, Flow measurement, *Waste dilution.
Identifiers: *Combined sewers.

A method is described for calculating the discharge of storm water from combined sewerage systems in relation to the flow of the receiving stream.

314

### POLLUTION PREVENTION IN NORTHERN IRELAND.

T. R. Graham.
Effluent Water Treat J, Vol 7, No 1, pp 35-37, Jan 1967.

Descriptors: *Water pollution, *Storm runoff, *Overflow, Rainfall intensity.
Identifiers: *Combined sewers, *Storage tanks, Northern Ireland.

A general report on current water quality conditions in Northern Ireland at a time of intense expansion involving the growth of cities, creation of a city, construction of a motorway network, and the doubling of ferry capacity between Britain and Northern Ireland is presented.

The need for future legislation that will prevent and control pollution from industrial and agricultural effluents is stressed. Where there are combined sewers, high rainfall in some areas causes much direct pollution from storm sewage and prevents adequate retention time of storm water at the works. New development areas have separate sewage systems. In a few areas storm-water is settled by tanks at the overflow, with occasional desludging.

315

### THE RETENTION OF POLLUTING MATTER FROM STORM OVERFLOWS.

H. Guntzel.
Gesundh Ing, Vol 56, 1933.

Descriptors: *Storm runoff, *Water pollution, *Overflow, Weirs, Design.
Identifiers: *Suspended solids.

Discusses the effect on streams of polluting matter carried by storm water from sewer overflows, conditions of flow at overflow weirs, different methods of retaining solid matter (screens, settling tanks, baffles, etc.) and their advantages, disadvantages and possible improvement. A design of overflow is suggested in which the overflow water passes through screens inclined at such an angle that the screening can be returned by an automatic scraper. The installation of a screening plant permits the discharge of greater quantities of storm water into a stream as the dilution necessary is less for screened than for unscreened storm water. The economics of storm water treatment are discussed.

316

### SEDIMENT IN SMALL RESERVOIRS DUE TO URBANIZATION.

H. P. Guy and G. E. Ferguson.
ASCE Proc, J Hydraul Div, Vol 88, No HY 2, 1962.

Descriptors: *Land use, *Sedimentation.
Identifiers: *Urban drainage.

Increasing urban development may cause severe silting in small reservoirs downstream from such developments. A typical example is that of lake Barcroft, near Washington, D. C., where 19 acre-ft or 25,000 tons of sediment have been deposited for each square mile of completed residential construction. Factors affecting sedimentation in urbanized areas are listed; these are similar to those occurring under rural conditions, but are more difficult to evaluate. Material deposited in a reservoir after urban construction will probably be coarser than that associated with rural conditions.

317

## DETOURING CALAMITY IN WATER RESOURCE DEVELOPMENT. A CASE IN POINT: SOUTHEASTERN WISCONSIN.

S. W. Havlick.
Trans Wis Acad Sci Arts Lett, Vol 55, pp 59-76, 1966.
(through Water Pollut Abstr, Vol 41, No 5, p 194, May 1968).

Descriptors: *Water pollution control, Recreation facilities, groundwater, *Sewers.
Identifiers: *Sewer separation, *Storm sewers, *Sewer infiltration, Milwaukee River, Wis.

After outlining difficulties encountered in the development and management of water resources, including the control of water quality the author analyses the situation in southeastern Wisconsin with particular reference to the potential utilization of water in the Milwaukee river basin and possible methods for solving the pollution problem. The Milwaukee river is used for industrial water supplies and recreational purposes, but not for potable supplies. Adequate supplies are available from lake Michigan although the costs of treatment are increasing, partly owing to deterioration in water quality. Further deterioration in quality of lake and river water could be prevented by increased waste treatment, separation of sanitary and storm sewers, and elimination of ground-water infiltration into the sewerage system. It is also proposed that the increasing demand for recreational facilities could be met by further development of lakes and reservoirs within easy access, and that flood water from a loop of the Milwaukee river could be diverted into lake Michigan and used subsequently to augment the river in dry weather.

318
## SOURCES AND CONTROL OF RIVER POLLUTION.

R. D. Hoak.
Instrum, Vol 25, No 12, pp 1714-6, Dec 1952.

Descriptors: *Storm runoff, *Water pollution, Water pollution control, *Instrumentation.
Identifiers: *Urban drainage.

Five principal sources are erosion, storm water runoff from urban areas, domestic sewage, industrial waste and acid mine waters; varieties of pollution which result from these causes; extent of stream self-purification; pollution control and types of instruments applicable.

319
## KANSAS CITY'S POLLUTION ABATEMENT PROGRAM.

G. J. Hopkins.
Water Pollut Contr Fed J, Vol 9, pp 1487-1503, Sept 1967.

Descriptors: *Water pollution control, Sewage sludge, Sewage treatment, *Storm runoff, Pumping, *Overflow.
Identifiers: *Combined sewers, Sewer separation, *Kansas City, Mo., Missouri River.

Kansas City, Mo., is carrying out a $75 million program to abate pollution of the Missouri River and its tributaries in the area. The program is financed by revenue bonds supported by a sewer service charge. The plan is geared to joint use of facilities by Kansas City and the numerous adjacent municipalities. Primary treatment of all wastewater is now in effect. The facilities now completed include four treatment plants and a number of pump stations, force mains, and interceptor sewers. Sewers will be extended to presently underdeveloped areas. Unusual features include a sewer river crossing, use of an abandoned water main as a sewer force main, and pumping of sludge 7 miles (11.3km) for treatment at a central facility. Waste treatment is unlikely to provide a total solution to the Missouri River's water quality problems. There is no demonstrable need or economic justification for stormwater separation for the Missouri River. Quality of stormwater overflows may compare favorably with that of the receiving water. These overflows occur less than four percent of the time and their pollutional significance has not been demonstrated.

320
## PROBLEMS IN THE PLANNING OF SEWAGE WORKS.
A. Hörler.

Schweiz Z Hydrol, Vol 19, 243, 1957.

Descriptors: *Sewage effluent, Sewage treatment, *Overflow, *Storm runoff, *Water pollution.
Identifiers: *Storage tanks, *Combined sewers.

The planning of sewage disposal should be based on topographical and not political divisions. Methods of determining the amount of sewage are described. Combined and separate sewerage systems are compared, and the effect on the receiving stream of storm overflows and the improvement obtained by stormwater storage tanks are discussed. The amount of storm water which should receive complete treatment is then considered.

321
## RIVER-WATER QUALITY CRITERIA IN RELATION TO WATERWORKS REQUIREMENTS.

G. V. Houghton.
Paper presented at the Symp on River Management, Univ of Newcastle upon Tyne, Sept. 1966.

Descriptors: *Water quality, *Rain, Chemical analysis.
Identifiers: *Storage tanks.

The type of criteria or tests required to provide satisfactory cleanliness for waterworks requirements are reviewed. The equalizing and purifying effects of rain water storage have always been recognized as beneficial, depending on many factors. If there is no storage, the setting of criteria is simplified in that it is known that every peak of river impurity must be handled effectively or else abstraction stopped. Some caution is warranted with toxic substances - nitrates, phosphates and polyphosphates, excremental bacteria, organic content and miscellaneous industrial pollution - since storage can have a profound effect on the concentration of some impurities. The need for sufficiently sensitive and reproduceable analytical procedures is discussed.

322

## AQUIFER RECHARGING.

L.T. Hunziker.
Water Sewage Works, Vol 111, pp 203-205, 1964.
(through Water Pollut Abstr, Vol 38, No 10, p 325, Oct 1965).

Descriptors: *Groundwater recharge, *Storm runoff, Water pollution.

In a review of recharging of aquifers, various methods are described including diffusion wells and seepage lagoons using settled storm water. The quality of the water for recharge, geological conditions and the dangers of pollution are discussed briefly.

323

## OIL-SEPARATOR TANKS FOR MOTORWAYS IN THE RUHR VALLEY.

K.R. Imhoff.
Gas Wasserfach, Vol 108, pp 43-45, 1967.
(through Water Pollut Abstr, Vol 40, No 7, p 291, July 1967).

Descriptors: *Highways, *Runoff, *Water pollution, *Storm runoff.
Identifiers: *Storm sewers, Capacity, *Oil pollution.

In connection with the prevention of pollution by oil, deposited on motorways by the increasing number of oil tankers, and washed-off into the receiving waters by rainfall, detailed studies were carried out by the Ruhrverband on the Westhofer motorway between Remscheid and Kamen. Oil-separator tanks have been installed along sections of the new motorway before the storm sewage enters the receiving water to protect numerous water works in the lower and middle Ruhr, which serve a large community. Based on the specification DIN 4040 and 4043 of the Ruhrverband, these tanks are constructed for a surface loading of 12 m per hour and a retention period of 10 min; the calculation of the run-off is based on 100 litre per second per hectare. The run-off values and time factor are adjusted to local conditions. Successful operational results showed that 6 months after installation a 4-cm deposit of sludge and 1-2m$^3$ of sand had collected from each influent and these were easily withdrawn by suction pumps. Tabulated data are included and a map shows the areas selected for present and future positions of separator tanks.

324

## PATHS OF POLLUTION IN NEW YORK HARBOR-MODEL STUDY.

W. T. Ingram and H. Mitwally.
Water Pollut Contr Fed J, Vol 38, No 10, pp 1563-81, Oct 1966.
(through Eng Index, p 2900, 1967).

Descriptors: *Path of pollutants, *Model studies, *Water pollution, *Storm runoff, Overflow, Estuaries.
Identifiers: New York, N Y.

Extensive study utilized dye releases in model of New York Harbor to trace paths followed by pollutants discharged at particular points. Influences of installed jetties and dikes on pollution paths and relationship between release concentrations at source of pollution developed by individual tests and those shown by simultaneous release from multiple sources were investigated. Pollution sources were wastewater treatment plants and stormwater overflows. This type of study is useful in predicting effects on pollution paths of changes in harbor configuration and waste discharge before such changes actually are made in prototype.

325

## NATION'S CAPITAL ENLARGES ITS SEWERAGE SYSTEM.

C. Frank Johnson.
Civ Eng, Vol 28, No 6, 1958.

Descriptors: *Water pollution, *Overflow, Recreation facilities, *Pumping, *Storm runoff.
Identifiers: *Interceptor sewers, *Combined sewers, *Washington, D.C., *Sewer separation.

Pollution from combined sewer overflows is prohibiting the use of Potomac and Anacostia Rivers and Rock Creek in Washington, D.C. for many recreational uses. A $151,000,000 improvement program is recommended, mostly for relief sewers and pumping stations. Some of the interceptors are so inadequate that they overflow even in dry weather. The separation of all sewers was considered but concluded to be too costly. Alternate plan is to construct large enough relief sewers that overflows into Rock Creek will have a dilution factor of 200 and Upper Potomac 30 before overflowing. This represents a storm of 2 year frequency.

326

### SLUDGE DEPOSITS IN STREAMS FROM STORM WATER OUTLETS.

W. Kiefer.
Neue Deliwa Z, Vol 3, p 71, 1959.

Descriptors: *Storm runoff, *Overflow, *Sewage sludge, Waste dilution.
Identifiers: *Combined sewers, Storage tanks.

The author describes by means of an example a method for estimating the effect of storm-water overflows on sludge deposits in streams. From comparison of overflows of different types it appears that overflows from combined sewerage systems with five-fold dilution add, on a yearly average, less load to the stream than separate systems. Use of storm-water sedimentation tanks, the ideal solution, is not always possible. In general it is unnecessary for such tanks to have a retention period of more than 10 min. The self-purifying power of the stream must be taken into consideration.

327

### THE POLLUTION OF RUN-OFF FROM URBAN HOUSING ESTATES.

H. E. Kurzweil.
Gesundh Ing, Vol 85, 178, 1964.

Descriptors: Runoff, Rainfall-runoff relationships, *Rainfall intensity, *Water quality, *Biochemical oxygen demand, *Dissolved oxygen, *Water pollution, Sewage treatment, *Storm runoff.
Identifiers: *Urban drainage, *Storm sewers.

Based on studies of rainfall and run-off in urban areas, during storms of varying intensity, results are given on the changes in the quality of water from roofs and paved areas, including data on 5-day B.O.D., dissolved oxygen, and organic substances. The discharge of this polluted water to the stormwater sewer or sewerage system is discussed and the author recommends preliminary treatment of this run-off to reduce pollution.

328

## CHEMICAL CONTROL OF WATER QUALITY IN A TIDAL BASIN.

M. Lang.
Water Pollut Contr Fed J, Vol 38, pp 1410-1418, 1966.
(through Water Pollut Abstr, Vol 39, No 12, pp 426-7, Dec 1966).

Descriptors: *Storm runoff, *Overflow, *Water pollution, Sewage treatment.
Identifiers: *Interceptor sewers, Bergen Basin, N Y.

Bergen basin, a small arm of Jamaica bay, N.Y., is a tidal basin with no surface-water tributaries, but it receives discharges of storm sewage when the capacity of the nearby Jamaica sewage works is exceeded during storms, and at times in hot weather there has been slight odour nuisance. In 1963, when alterations were being made to the sewage works, all the plant effluent was discharged to the basin for 2 weeks; at this time the influent sewage was septic, having been stored in the intercepting sewers for some months while the alterations were in progress, and this caused severe pollution of the basin with very strong evolution of hydrogen sulphide. In an attempt to improve conditions, bulk sodium nitrate was added to the basin to create aerobic conditions in the bottom deposits, and sodium hypochlorite solution was also added to oxidize the hydrogen sulphide in the water; these measures proved effective, and subsequently addition of hypochlorite was discontinued, but sodium nitrate is still being added to the basin.

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## EFFECT OF STORM OVERFLOWS ON RIVER QUALITY.

W.F. Lester.
Paper presented at the Symp on Storm Sewage Overflows, May 4, 1967.
Sponsored by the Inst Civ Eng.

Descriptors: *Water quality, *Overflow, *Storm runoff, Dicharge (water), *Water pollution.
Identifiers: *Storage tanks.

It is assumed that the "standard" storm sewage overflow in excess of 6 d.w.f. flows to a river which has a rate of flow of 1, D, and 100 times d.w.f. of the sewage. It is shown that the quality change with increase in rate of flow will depend on the initial quality of the stream. A table indicates the quality of river water below storm overflows. Because the discharges contain more carbohydrates and higher organic compounds than fully treated effluent there is a greater tendency to form fungal growths below overflows. The discharge of E. coli. content increases. The concentrations of toxic materials may be critical from sewers containing industrial wastes. Where rivers are used for direct abstraction of water for potable supplies, overflows cause rapid changes in quality. Fractured sewers can also cause pollution of rivers. The discharges from "standard" storm tanks will have as much as 80% reduction in pollutional effects on rivers. Brief reports are made on surveys of the River Trent and Tame to determine the effect of storm discharges on these two rivers.

330

### PROBLEMS IN THE CALCULATION OF STORM WATER OVERFLOWS.

W. Losse.
Gas Wasserfach, Vol 29, pp 84-5, 1958.

Descriptors: *Storm runoff, *Overflow, Water pollution, *Rainfall intensity, Design.

The author discusses, from personal experience and from the literature, the amounts of rainfall for which storm water overflows should be designed in order to avoid pollution of the receiving stream. Amounts between 6-10 liters/sec./ha are suggested, varying according to the stream, the slope of the land, and the condition of the sewerage system. The figures must be tested by careful investigation. Calculation of storm water overflows according to amounts of rainfall is preferable to calculation by a mixing ratio which may give a false impression of the load of the stream.

331

### THE STORM-SEWAGE POLLUTION PROBLEM.

C. Lumb.
Inst Sewage Purif J Proc, 1964, Pt 2, p 168, 1964.

Descriptors: *Storm runoff, *Overflow, *Water pollution, Design, Sewers, Sewage treatment.
Identifiers: *Combined sewers, *Sewer separation, *Storage tanks.

The author discusses the polluting effects of storm-sewage overflows from combined sewerage systems and methods for reducing such pollution, including the installation of separate sewerage systems, the use of overflow settings higher than the conventional 6 times dry-weather flow, improved design of overflows, screening of storm sewage, and provision of storage facilities at overflows to receive the first flush of the discharge and return it later to the foul sewer. Pollution may also be caused by discharges of partially treated storm sewage from storm-sewage tanks at sewage works; this can be reduced by increasing the flows to be given full treatment and by improved design and operation of storm-sewage tanks.

332

### STORM WATER POLLUTION CONTROL.

Div of Water Supply & Pollut Contr PHS, HEW, Washington, D. C.
Gordon E. McCallum and Leo Weaver.
Paper presented at the Interstate Conf on Water Problems, Dayton, Ohio, Dec 10, 1965. 9 p 12 ref.

Descriptors: *Storm runoff, *Water pollution, Sewage treatment.
Identifiers: *Combined sewers, *Storm sewers, *Sewer separation, storage tanks.

Inadequacies of combined sewage systems are discussed. Pollution by storm water runoff is described. Government grant projects aimed at solving this problem are outlined. The costliness and relative insufficiency of complete separation of storm sewers from sanitary sewers is mentioned and the need for new alternative solutions (e.g. holding tanks, treatment) emphasized.

333

### ADMINISTRATIVE AND FINANCIAL ASPECTS OF OPERATING A METROPOLITAN SEWER DISTRICT.

Metropolitan St Louis Sewer Dist, St Louis, Mo.
P.F. Mattei and C. B. Kaiser.
Water Pollut Contr Fed J, Vol 39, No 4, pp 501-517, Apr 1967.

Descriptors: Watersheds, *Storm runoff, *Water pollution control, *Construction costs, Outlets, Drainage systems, Sewage treatment.
Identifiers: *Urban drainage, *Interceptor sewers, *St. Louis, Mo.

The organization and financing of the 12 yr. old Metropolitan St Louis Sewer District are described. A watershed by watershed study was made to determine the stormwater problem and results have shown what the district needs but the more than a hundred million dollars overall cost necessitates a piecemeal approval, dealing with the worst problems through subdistrict programs and self-help programs. To relieve pollution of the Mississippi by sewage, construction of an interceptor sewer picking up all of the wastewater outlets along the river was begun as well as construction of two large primary treatment plants. Problems and possible solutions for financing the needed storm-water facilities are discussed.

334
THE MINNEAPOLIS-SAINT PAUL SANITARY DISTRICT - OPERATION AND EXPANSION.

K.L. Mick.
Water Pollut Contr Fed J, Vol 39, No 10, pp 1684-1700, Oct 1967.
1 fig, 3 tab, 6 ref.

Descriptors: *Sewage treatment, Grants, *Overflow, Construction costs, Water pollution.
Identifiers: *Interceptor sewers,*Storm sewers, *Combined sewers, Minneapolis-St. Paul, Minn.

Results of a 1956-60 study of the Minneapolis-St. Paul Sanitary District called for central treatment of wastewater at the existing plant, plant expansion, and interceptor sewer construction. Estimated costs are given. Expansion of the existing primary plant is discussed. A study on the combined sanitary and storm sewer problem was also included. The study recommended that a system of power-operated gates be installed on 15 key regulators, with gate positions and levels in major sewers telemetered to a central control point. These 15 diversion points accounted for about 80 percent of the overflow to the river in 1960. In 1966 the District received a Federal demonstration grant offer of 50 percent for a sewer regulator project estimated to cost $1,741,500. This work will include an evaluation of the effect on river conditions. A supervisory control system will promote maximum utilization of the interceptor sewer system and treatment facilities, taking into account rainfall distribution in the area and other factors. It will provide a new technique of instantaneous observation and control of interceptor system performance to minimize overflows to the river.

335

## OVERFLOWS FROM COMBINED SEWERS IN WASHINGTON, D.C.

G.J. Moorehead.
Water Pollut Contr Fed J, Vol 33, 711, 1961.

Descriptors: *Overflow, *Storm runoff, Estuaries.
Identifiers: *Combined sewers, *Sewer separation, *Washington, D.C., Potomac River.

The older part of Washington, D.C. is served by a combined sewage system which discharges a mixture of sanitary sewage and storm water into local streams and the Potomac river during each nominal rainfall, while overflows of sanitary sewage sometimes occur during hot dry weather. After a review of the development of the sewerage system, the author outlines a study which was carried out recently to determine the precentage of sanitary sewage flow which is discharged through storm-water overflows. As a result of the study it is planned to provide some separation of sanitary and storm-water sewers, with the majority of the existing storm-water overflows on the combined system remaining in limited acceptable service. This is expected to reduce the amount of sanitary sewage discharging to the watercourses in the area from 3.3 percent to 0.4 percent of the total flow.

336

## [SEWAGE LOAD OF RECEIVING STREAMS FROM MIXED SEWERS]. Die Abwasserbelastung des Vorfluters durch Mischkanalisationen. (in German).

H. H. Mueller.
Gas Wasserfach, Vol 109, No 6, pp 143-147, 1968.

Descriptors: *Water pollution, Sewage treatment, *Storm runoff, *Overflow.
Identifiers: *Calculations, *Storage tanks, *Capacity, *Combined sewers.

Investigations into the determination of the amount of impurities which are annually introduced, under specific combinations of control measures, into receiving streams are described. Fundamental theories and assumptions are presented, followed by the corresponding calculations. The balance of impurities shows that the introduction of rainwater settling tanks into the treatment considerably increases the efficiency which also depends on the chosen critical rainfall and the size of the tanks. The $(1+4)Q_s$ infeed to the plant is observed.

In size determinations, consideration should preferably be given to a critical rainfall of 10 to 15 l/s.ha. Rainwater hold-up time in the settling tanks should be at least 10 minutes. However, if it is possible to install a large collecting main with a high threshold for the rainwater overflow, an equivalent effect would be obtained with a hold-up time of about 3 minutes for the maximum infeed.

337

DISCHARGE OF RAIN WATER FROM URBAN SEWERS INTO STREAMS.

M. Negulescu and I. Rabinovici.
Hidroteh, Vol 9, pp 205-209, 1964.
(through Water Pollut Abstr, Vol 40, No 6, pp 256-7, June 1967).

Descriptors: *Storm runoff, *Water pollution, Discharge (water), *Water pollution control.
Identifiers: *Urban drainage, *Combined sewers, *Storage tanks.

It is indicated that rain water discharged from combined or separate sewers in urban areas can have as great or even double the polluting effect of domestic sewage and can damage the receiving stream particularly if the areas are industrial. Storage reservoirs along the sewerage system or as part of the treatment plant are suggested as a means of protecting streams.

338

ANALYSIS OF DISSOLVED OXYGEN DISTRIBUTION IN EAST RIVER.

D. J. O'Connor.
Water Pollut Contr Fed J, Vol 38, No 11, pp 1813-30, Nov 1966.
(through Eng Index, p 2884-5, 1967).

Descriptors: *Water quality, *Storm runoff, *Overflow, *Dissolved oxygen, Biochemical oxygen demand.
Identifiers: *Calculations, East River, N Y.

Analysis of water quality in East River, New York, by mathematical model consisting of linear differential equations produced results agreeing generally with observation of actual conditions. Storm overflows and sludge deposits appear to have significant effects. Spatial profile of DO is directly related to wastewater discharges and temperature distribution during summer. Future work will require more accurate measurements of sludge deposits, storm overflows, nitrogenous and carbonaceous BOD components, exchange and dispersion coefficients, and other parameters.

339

### THE POLLUTIONAL EFFECTS OF STORM WATER OVERFLOWS FROM COMBINED SEWERS.

C. L. Palmer.
Sewage Ind Wastes, Vol 22, pp 154-65, 1950.

Descriptors: *Water pollution, *Storm runoff, *Overflow, Rainfall intensity, Water pollution control.
Identifiers: *Combined sewers, Capacity, *Interceptor sewers.

The author discusses the effects of pollution caused by overflowing of storm water from a combined sewer system. The characteristics of low intensity storms in the Detroit area were first studied and the results shown in graphs. It was found that runoff did not occur unless precipitation was greater than 0.03 in/hr and storm water would not overflow unless precipitation was more than 0.03 in/hr. plus the capacity of the sewers for storm water. It was found that intercepting sewers are most effective in preventing overflow when they have a capacity of 150% of the sewage flow, and no satisfactory reduction in number of duration of overflows is achieved by increasing the capacity to any reasonable extent. The quality of the overflowing liquid varies considerably and would be highly polluting even from a separate system, the cost of which is not commensurate with the reduction in pollution which it would effect. A properly designed combined sewerage system should be about 99% effective in preventing pollution by storm water overflows.

340

## SEWERAGE SYSTEMS AND RIVER POLLUTION.

J. A. Pickford.
Roy Soc Health J, Vol 87, No 1, pp 36-42, Jan-Feb, 1967.

Descriptors: *Water pollution, *Discharge (water), *Rainfall intensity, *Storm runoff, *Overflow, Sewers, Water pollution control.
Identifiers: *Combined sewers, *Storm sewers, *Sewer separation, *Capacity.

The effect of discharge of combined, separate, or partially separate sewer systems on river pollution is discussed. Factors affecting the quantity of storm sewage are rainfall and run-off, overflow devices, and the storage capacity of sewers. Several overflow devices are discussed. It is suggested that the increase of treatment plant capacity, the provision of larger sewers, and the provision of selective types of overflow are likely to cost much less than the provision of completely separate systems, and that pollution can be more effectively controlled by these methods.

341

## THE BATTLE TO SAVE LAKE MICHIGAN.

H. W. Poston.
Civ Eng, Vol 37, No 12, pp 40-43, Dec 1967.

Descriptors: Sewage treatment, *Overflow, *Water pollution control, *Flow measurement, Storm runoff.
Identifiers: *Combined sewers, *Interceptor sewers, *Storage tanks, *Chicago, Ill., *Lake Michigan.

As a result of an enforcement conference called by the Federal Water Pollution Control Administration, Indiana communities whose waste dump into Lake Michigan have already added secondary treatment facilities; detention facilities and combined sanitary-storm sewers are to be built to prevent overflow. Chicago is attempting to solve this problem by retaining storm water overflows in underground interceptor sewers of large diameter 250 ft. deep, where the water can be stored for future treatment. Milwaukee is establishing automatic monitors along the Milwaukee River to measure the average yearly flows and peak flows of the sewer system as affected by rainfall in an attempt to locate critical points where control facilities should be installed. In addition, a 3.8 million gallon underground detention tank will be constructed to trap storm overflows, which will be retained for subsequent treatment.

342
## MERRIMACK RIVER POLLUTION ABATEMENT STUDY.

P. W. Prendiville.
Boston Soc Civ Eng J, Vol 51, pp 316-328, 1964.
(through Water Pollut Abstr, Vol 39, No 7, p 249, July 1966).

Descriptors: *Storm runoff, *Overflow, *Water pollution control, Sewer treatment, Sewer lagoons, Estuaries.
Identifiers: Merrimack R, Mass.

In view of the increasing pollution of the Merrimack river, which is formed in New Hampshire by the confluence of the Pemigewasset and Winnipesaukee rivers and flows through Massachusetts to the Atlantic ocean, surveys have been carried out to determine the present condition of the river and the degree of treatment required for sewage and trade waste waters discharged to it. The results of the investigations on the extent of organic and bacterial pollution and the polluting effects of overflows of mixed sewage and storm water are discussed briefly. Various alternative plans for sewage treatment have been considered, and it was recommended that the individual communities and metropolitan regions should be responsible for constructing the necessary sewage-treatment facilities; these would include extended-aeration plants, primary treatment plants, and sewage lagoons. An industrial survey showed that all the trade waste waters in the area can be treated in the municipal plant, after preliminary treatment at the source in some cases.

343
## POLLUTION STUDY OF A FUTURE TIDAL ESTUARY.

C. A. Rambow.
Water Pollut Contr Fed J, Vol 36, pp 520-528, 1964.
(through Water Pollut Abstr, Vol 37, No 10, pp 358-9, Oct 1964).

Descriptors: *Estuaries, Surface runoff, *Flood control, *Dissolved oxygen, *Path of pollutants, Outlets, *Biochemical oxygen demand.
Identifiers:*Los Angeles, Calif.

Dominguez channel is a natural watercourse carrying surface run-off and waste discharges from an area south-west of Los Angeles into the east basin of Los Angeles Harbour. During heavy rainstorms, flooding occurs, and the lower portion of the channel is now being improved to control this. The design is such that the invert will be below mean sea level for a distance upstream of more than 8 miles, and the finished channel will therefore constitute a tidal estuary. At present the waste waters discharged to the channel are too strong for biochemical action to occur, but when diluted with a large volume of sea water it is possible that biochemical degradation will occur in the channel, with depletion of dissolved oxygen and formation of odours. Theoretical analysis was, therefore, used to estimate the waste-assimilating capacity of the improved channel; this involved calculation of the spread of pollutants from the various outfalls, estimation of the oxygen resources of the channel, and comparison of oxygen demand with oxygen resources to determine the most critical point of the channel. By equating B.O.D. to oxygen supply at this point, an oxygen sag curve for the channel was obtained for the calculated B.O.D. loadings; this curve can be used as the basis for siting future outfalls and for determining the allowable discharge of B.O.D. by various industries.

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### EVALUATION OF DISPERSED POLLUTIONAL LOADS.

G. W. Reid and J. Cleveland.
ASCE Environ Eng Conf-Preprint 422, Feb 6-9, 1967. 10 p.
(through Eng Index, p 2897, 1967).

Descriptors: *Storm runoff, *Land use, *Water quality, *Runoff.
Identifiers: *Calculations, *Urban drainage, Tulsa, Okla.

Experimental technique proposed is to determine quality of storm water from individual drainage basins that make up urban Tulsa City-County, Okla, and by using component analysis technique, evaluate effects of land use practices on quality of runoff. Stream is sampled twice monthly during dry weather flow, and several times during storm runoff period. It is estimated that at least 1 or possibly 2 yr of data will be needed to make representative estimation of true quality and quantity of runoff. Principal components of many variables will be estimated by component analysis technique Knowing principal component regression analysis can be used to determine best model and predictive equation.

345

EUTROPHICATION OF ESTUARINE AREAS BY RAIN WATER.

R. J. Reimold and F. C. Daiber.
Chesapeake Sci, Vol 8, pp 132-133, 1967.
(through Water Pollut Abstr, Vol 41, No 5, p 203, May 1968).

Descriptors: *Chemical analysis, Rain, Storm runoff, *Estuaries, *Eutrophication, Water quality.
Identifiers: *Atlantic Coast, United States.

Tabulated and graphical results are given of analyses of total phosphorus in rain water at Lewes, Del., from February 1966 to January 1967; the mean concentrations, per litre, were 4.9 μg-atom in winter and spring, 150 μg-atom in summer, and 8.1 μg-atom in autumn and winter. Possible causes of the sudden increase after April are discussed, and it is suggested that this is the reason for the unusual phosphorus cycles found in bay waters and marshes along the east coast of U.S.A., providing an extra source of nutrient during spring and summer when productivity tends to be higher.

346

HOW COMBINED SEWERS AFFECT WATER POLLUTION. PT 1.

Harold Romer and Lester M. Klashman.
Public Works, Vol 94, p 100, Mar 1963.

Descriptors: *Water pollution, Sewage treatment, *Design, Discharge (water).
Identifiers: *Combined sewers, *Urban drainage, Capacity.

This article on studies of pollution of combined sewers discusses results of a questionnaire survey of 148 cities, 80 of which replied (50,000-2,100,000 population). The 11 questions deal with characteristics of combined sewage, combined sewer and treatment plant capacities and design, combined sewage treatment practices, and effects of combined sewage discharges on quality of receiving waters.

347
### HOW COMBINED SEWERS AFFECT WATER POLLUTION. PT 2.

Harold Romer and Lester M. Klashman.
Public Works, Vol 94, p 88, April 1963.

Descriptors: *Water pollution.
Identifiers: *Combined sewers, *United States, *Great Britain.

This concluding report on the pollution problems created by combined sewer discharges to waterways during overload periods, cites results of specific studies in the United States and England.

348
### THE INFLUENCE OF COMBINED SEWERS ON POLLUTION CONTROL.

Harold Romer and Lester M. Klashman.
Public Works, Vol 92, No 10, p 129, 1961.

Descriptors: *Water pollution, *Overflow, Design, Surface runoff, *Storm runoff.
Identifiers: *Combined sewers, *Suspended solids, *United States, *Great Britain, *Storage tanks.

In discussing the polluting effects of overflows from combined sewers, the authors review American and British practices concerning the use of storm-water tanks and summarize British recommendations for the design and operation of combined sewerage systems. Data are given to illustrate the effect of storms on the concentration of suspended solids in storm-water sewage, and the results of studies on quality of surface run-off are reviewed. The use of storm-water tanks in America in being considered.

349
THE PERMISSIBLE DILUTION AT STORM WATER OUTLETS.

W. Scharfe.
Wasserwirtsch - Wassertech, Vol 5, p 243, 1955.

Descriptors: *Storm runoff, *Overflow, Outlets, Construction, Water pollution.
Identifiers: *Dilution, Storage tanks.

The author points out that a dilution ratio for storm water overflows of 1:7 may not in all circumstances afford protection to the stream. Local rainfall, by stirring up deposits, may result in the discharge of a liquid more concentrated than normal sewage. Special attention must be paid to the construction of the outlets and to the provision of retention tanks. Increasing the ratio would give sewers of uneconomic size.

350
ENVIRONMENTAL EFFECTS OF HIGHWAYS.

M. E. Scheidt.
ASCE Proc, J Sanit Eng Div, Vol 93, No SA 5, Pap No 5509, pp 17-25, 1967.
(through Water Pollut Abstr, Vol 41, No 6, p 282, June 1968).

Descriptors: *Highways, *Water pollution, Construction, *Surface runoff.

The author discusses the various polluting effects of highways on the natural environment. The greatest source of pollution is erosion during construction of the highway, which can cause considerable damage downstream, and measures to control such erosion are required during the construction of federal and federal-aided highways. Other sources of pollution are chemicals used to melt ice and snow and to control roadside vegetation, spills from vehicles involved in accidents, and run-off from paved areas.

351

## POLLUTION OF CITY SURFACE RUN-OFF WATER.

G. G. Schigorin.
Vodosn Sanit Tekh, No 2, pp 19-20, 1956.

Descriptors: *Water pollution, *Storm runoff, *Cities, Rainfall intensity, *Storm drainage.
Identifiers: *Storm sewers, Suspended solids, *Russia, Urban drainage.

To study the polluting effect of run-off from paved areas, samples of storm water collected from the separate storm-water sewers in Vasileostrovsk, U.S.S.R., and of water from street rain receivers after paved streets had been washed with automatic sprinklers, were analysed; the results are tabulated. Marked fluctuations in the concentrations of suspended solids are attributed to the differing degrees of dirtiness of different streets. Heavy rain did not appear to reduce the polluting effect of later run-off, probably because pollution intensities at the points of origin (road sweepings, products of breakdown of pavements, and air-borne contaminants) were relatively constant. Surface run-off from cobbled streets with comparatively light traffic was much less polluting than run-off from asphalt-paved streets with heavy traffic. The need for preliminary treatment of such run-off to reduce pollution of the receiving streams is stressed.

352

## EFFECTIVENESS OF THE INTERCEPTION OF SEWAGE--STORM WATER MIXTURES.

Walter G. Shifrin.
Univ Missouri Bull, Eng Ser Bull #47, Vol 61, No 8, pp 8-12, Feb 12, 1960.

Descriptors: *Storm runoff, *Overflow, Water pollution control.
Identifiers: *Combined sewers, Calculations, *Interceptor sewers, *Capacity, *St. Louis, Mo.

Since it is not economically feasible to intercept and treat all sewage-storm water runoff mixture, the study reports on determination of proper interception factor. Average daily sewage flow was converted to an equivalent rainfall of 0.007 in/hr/acre for the area drained by combined sewers. Peak sewage rate was taken as 136% of average or 0.0095 in/hr/acre. Graphs and charts show the author's derivation of number of hours per year sewage would be bypassed. Author's conclusions based on specific case of St. Louis with overflows going to Mississippi River are that selection of interceptor capacities in excess of peak dry weather flow rate will produce an insignificantly small increase in the effectiveness of pollution abatement at a significant increase in the initial cost of the facilities.

353
EFFECTIVENESS OF THE INTERCEPTION OF SEWAGE-STORM WATER MIXTURES.

Walter G. Shifrin and W. W. Horner.
Water Pollut Contr Fed J, Vol 33, p 650, 1961.

Descriptors: *Water pollution control, *Sewage treatment, Storm runoff.
Identifiers: *St. Louis, Mo., *Combined sewers, *Interceptor sewers, Dilution, *Capacity, Urban drainage.

To reduce pollution of the Missouri and Mississippi rivers in the St. Louis metropolitan area, Mo., it is planned to provide primary treatment of sewage. Most of the sewerage systems in the area are of the combined type, and the authors describe the method used to determine the amount of the mixture of sewage and storm water which should be intercepted for treatment. As the Mississippi river provides considerable dilution and is not used for recreation nor as a source of water supply for some considerable distance below St. Louis, it is concluded that it is unnecessary to provide interceptor capacities in excess of the peak dry weather flow.

354
SEWAGE DISPOSAL IN THE REGION OF THE LOWER LAKE THUN.

W. Spring.
Gas Wasserfach, Vol 104, pp 1397-1398, 1963.
(through Water Pollut Abstr, Vol 38, No 9, p 303, Sept 1965).

Descriptors: Pumping, *Storm runoff, *Overflow, *Water pollution.

Attempts to maintain the purity of lake Thun, Switzerland, have resulted in communal sewage disposal. Owing to the geological position of the lake the sewage flows without pumping to the lower region, where it reaches the pumping station at Dürrenast and is then pumped into the treatment plant at Uetendort, near the Aare. Additional pumping stations are planned for Gwatt, Einigen, Spiez and Faulensee, and special reference is made to the problems of planning sewage works for the future, in which the population index should be considered. The author also discusses the effect of storm-sewage overflows on receiving waters.

355
STORM-WATER OVERFLOWS.

R. B. Stegmaier.
Sewage Works J, Vol 14, p 1264, 1942.

Descriptors: *Storm runoff, *Overflow, Flow measurement.
Identifiers: *Combined sewers, Baltimore, Md., *Suspended solids.

Studies were made of the storm water discharged from a combined sewer in Baltimore, Md., during six storms. The maximum amount of volatile solids and of total solids occurred at the maximum rate of flow.

356
THE EFFECT OF FRESH-WATER RUN-OFF ON A POPULATION OF ESTUARINE POLYCHAETOUS ANNELIDS.

A. N. Stone and D. J. Reish.
S. Calif Acad Sci Bull, Vol 64, pp 111-119, 1965.
(through Water Pollut Abstr, Vol 39, No 10, p 332, Oct 1966).

Descriptors: *Estuaries, *Storm runoff, Water pollution, *Bioindicators.
Identifiers: California.

Studies were carried out over a period of 15 months on the effect of run-off from rainfall on 3 species of estuarine polychaetes in Southern California. It was found that the worms were killed or reduced in numbers by rainfall in excess of 0.5 inch, but repopulation by larvae of the same species occurred rapidly.

357
EFFECTS OF WINTER STORM RUNOFF ON VEGETATION AND AS A FACTOR IN STREAM POLLUTION.

Richard H. Sullivan.
Paper presented at the 7th Annual Snow Conf, Milwaukee, Wis, Apr 12, 1967.
6 p. Sponsored by the Amer Public Works Assoc Res Foundation.

Descriptors: *Chemical analysis, *Storm runoff, *Highways.

A determination of chloride content of storm water discharge from a section of the Kennedy Expressway in Chicago during the winter of '66-7 was carried out. Methods & results are given. Salt from snow clearing operations can cause occassional high salt concentrations. Results of tests on storm water from an area in which Cargill's Carguard was used as a corrosion inhibitor are given. Other studies on the effect of chlorides on vegetation are discussed.

358
A LAKE'S RESPONSE TO ITS ENVIRONMENT.

Robert O. Sylvester and George C. Anderson.
ASCE Proc, J Sanit Eng Div, Vol 90, No SA1, Pt 1, Feb 1964.

Descriptors: *Water pollution, *Recreation facilities, *Runoff, Nutrients, Deterioration, *Storm runoff.
Identifiers: Dilution, *Urban drainage, Bacteriological sampling.

Green Lake in Seattle, Wash., was studied to find the causes underlying its heavy algae blooms and alleged condition of pollution so that its recreational potential might be realized. Data were obtained on urban runoff, lake shore runoff, subsurface inflow, algae populations, waterfowl, composition of sediments, effect of wind-induced currents on water quality, and requirements of competing recreational water uses. Water and nutrient budgets are presented. Nutrient additions sustain heavy algae blooms throughout most of the year, and little can be done to reduce these additions. Bacterial contamination is directly related to waterfowl populations. Changes in physical and chemical water quality are caused largely by algal growth and decay. Recommendations are given for the addition of low-nutrient city water for dilution purposes, for dredging, and for shoreline improvements. It is recommended that increased quantities of storm water not be added.

359
SEASONAL VARIATIONS IN SURVIVAL OF INDICATOR BACTERIA IN SOIL AND THEIR CONTRIBUTION TO STORM-WATER POLLUTION.
Natl Center Urban & Industrial Health, PHS, Cincinnati, Ohio.
Dale J. Van Donsel, Edwin E. Geldreich, and Norman A. Clark.
Appl Microbiol, pp 1362-1370, Nov 1967, 4 fig, 27 ref.

Descriptors: *Bioindicators, *Storm runoff, *Water pollution, *Coliforms.
Indentifiers: *Bacteriological sampling.

Survival of a fecal coliform (Escherichia coli) and a fecal streptococcus (Streptococcus faecalis var. liquifaciens) was studied through several years at shaded and exposed outdoor soil plots. Death rates for both organisms were calculated for the different seasons at both sites. The 90% reduction times for the fecal coliform ranged from 3.3 days in summer to 13.4 days in autumn. For the fecal streptococcus, 90% reduction times were from 2.7 days in summer to 20.1 days in winter. During summer, the fecal coliform survived slightly longer than the fecal streptococcus; during autumn, survival was the same; and in spring and winter the fecal streptococcus survived much longer than the fecal coliform. Both organisms were isolated from storm-water runoff collected below a sampling site when counts were sufficiently high in soil. Isolation was more frequent during prolonged rains, lasting up to 10 days, than during short rain storms. There was evidence of aftergrowth of nonfecal coliforms in the soil as a result of temperature and rainfall variations. Such aftergrowth may contribute to variations in bacterial count of storm-water runoff which have no relation to the sanitary history of the drainage area.

360
A STUDY OF LAKE MICHIGAN: CHEMICAL, BIOLOGICAL, AND PHYSICAL.

J. L. Verber.
Verh Int Verein Theor Angew Limnol, 1965, Vol 16, pp 29-46, 1966.
(through Water Pollut Abstr, Vol 40, No 8, p 338, Aug 1967).

Descriptors: *Water pollution control, *Overflow, *Storm runoff, Chemical analysis.
Identifiers: Oil pollution, *Lake Michigan.

Comprehensive investigations were made to determine the present water quality in lake Michigan and make recommendations for its preservation; some of the physico-chemical bacteriological and biological results are presented in tables and diagrams and discussed. Sufficient vertical mixing occurs during spring and autumn to distribute the chemical constituents uniformly throughout the water column. It is concluded that the lake is still oligotrophic but precautions must be taken to reduce the build-up of phosphates and nitrates in certain areas where municipal and trade waste waters are discharged, particularly in the southern basin where there appears to be a large semi-permanent clockwise gyral which tends to prevent dispersal of nutrients from the basin into the rest of the lake; chemical and biological differences between the northern and southern basins also indicate that horizontal mixing is very slow. The zone of poor-quality water along the coast near waste outfalls varies in width depending on the meterological conditions. Preliminary action has been taken to reduce pollution, especially that caused by storm-sewage overflows and by oily, phenolic, and other trade waste waters.

361

RELATIONS BETWEEN THE DEGREES OF DILUTION IN THE SEWERS AT THE STORM WATER OUTLET, AND IN THE RECEIVING STREAM.

F. Vomberg.
Gesundh Ing, Vol 74, pp 227-9, 1953.

Descriptors: *Design, *Storm runoff, *Overflow, Sewers.
Identifiers: *Calculations, Dilution.

The author discusses the calculations required in the design of storm water overflows and in the determination of their effect on the receiving stream.

362

STORM SEWAGE OVERFLOWS - A MAJOR POLLUTION SOURCE.

K. H. Walker.
Wastes Eng, Vol 33, No 8, Aug 1962.

Descriptors: *Storm runoff, *Overflow, *Water pollution.
Identifiers: *Combined sewers, Boston, Mass, New York, N Y.

This editorial stresses the need for further study and data to aid in solving the problem of storm sewage overflow. 1946 studies using Boston rainfall records show that sewage systems designed to handle 2 to 3 times average dwf would overflow 5-6 days/mo. The study also showed that with rainfalls of 0.20 inches/hr., nearly 90% of sanitary sewage would be discharged untreated. A New York City study showed that 60 to 80% of the raw sewage flowing through combined systems is discharged into the receiving waters once or twice a week.

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URBAN DRAINAGE AS A FACTOR IN EUTROPHICATION.
FWPCA, Cincinnati Water Research Lab, Cincinnati, Ohio.
S. R. Weibel.
Preprint, July 1967.

Descriptors: *Eutrophication, *Storm runoff, *Overflow, Water pollution, Nutrients, Sewers, Sewage treatment, Grants.
Identifiers: *Combined sewers, *Urban drainage.

Stormwater runoff and combined sewer overflows as sources of water pollution, including nutrient contributions are discussed. Maps show future urbanization patterns and present distribution of states and their communities served by combined sewer systems. Tables showing average concentrations and computed annual amounts of constituents, including nutrients, produced per square mile by the several sources such as rainfall, community sewage, urban stormwater runoff and combined sewer overflows, are presented. These indicate that all are significantly concentrated in some respect as to warrant consideration in appraising sources of pollution, particularly nutrients. In terms of relative production of nutrients per unit of area, community sewage heads the group, followed in order of decreasing unit production by combined sewer overflow, storm water runoff from a residential-commercial area and rainfall. Urban stormwater runoff as a water resourse is discussed. Comments on studies and practices representing the variety of efforts to control pollution from storm water runoff or combined sewer overflows are presented. Treatment of extraneous flows in sanitary sewers is also included. Government research contract and demonstration grant programs to provide assistance to qualified workers interested in contributing to methods for control of storm and combined sewer sources of pollution are outlined.

364

### URBAN LAND RUN-OFF AS A FACTOR IN STREAM POLLUTION.

S. R. Weibel, R. J. Anderson, and R. L. Woodward.
Water Pollut Contr Fed J, Vol 36, pp 914-924, 1964.
(through Water Pollut Abstr, Vol 38, No 4, p 127, Apr 1965).

Descriptors: *Water pollution, *Storm runoff, *Biochemical oxygen demand, *Turbidity, Chemical analysis, *Pathogenic bacteria, *Coliforms.
Identifiers: *Urban drainage, *Suspended solids, Surface permeability.

After reviewing briefly the work of other investigators on the composition and strength of run-off from urban areas, the authors describe a study carried out in part of Cincinnati, where about 37 per cent of the total drainage area is impermeable, the remainder being lawns, parks and gardens. The run-off had an average B.O.D. of 19 mg per litre, a turbidity of 170 units and a color of 81 units. The run-off was also found to contain organic chlorides, which could be derived from pesticides, and large numbers of bacteria, although faecal streptococci exceeded faecal coliform organisms, indicating predominantly non-human pollution. The highest concentrations of all contaminants occurred within the first 15 min of the start of run-off. These results confirm that run-off should be taken into consideration when estimating waste loadings from urban sources, and the authors stress the need for further studies to estimate the strength of run-off under various conditions.

365

### CHARACTERIZATION, TREATMENT AND DISPOSAL OF URBAN STORM WATER.

S. R. Weibel, R. B. Weidner, A. G. Christianson, et al.
Proc 3rd Int Conf Water Poll Res, Munich, 1966, Vol 1, pp 329-352, 1967.
(through Water Pollut Abstr, Vol 40, No 8, p 352, Aug 1967).

Descriptors: *Water pollution, *Storm runoff, *Chemical analysis, Rain, *Coliforms, Recreation facilities, *Sewage treatment, Chlorination, *Biochemical oxygen demand, Sedimentation, *Groundwater recharge.
Identifiers: *Urban drainage, *Suspended solids, Long Island, N Y.

The authors give further results of studies at Cincinnati, Ohio, on the polluting effect of run-off from urban areas, including investigations of the chemical composition of the rain falling on the study area. The rain water was found to contain, on average, 0.69 mg of inorganic nitrogen and 0.24 mg of hydrolysable phosphate, per litre; these concentrations exceed the threshold values found by other workers for the development of algal blooms. The rain water also contained about 0.28

µg of organic chlorine compounds per litre; DDT, DDE, and benzene hexachloride were identified. Analyses of the run-off, as reported previously, showed its pollution potential, and the concentrations of coliform organisms exceeded the criterion of 1000 per 100 ml recommended for bathing waters. Preliminary laboratory experiments on treatment of the run-off showed that sedimentation alone was not effective in reducing the BOD and suspended-solids content. Sedimentation for 20 min combined with chlorination at a dose of 4.62 mg of chlorine per litre killed more than 99 per cent of the bacteria; when the supernatant liquor was dechlorinated, however, and kept at room temperature for 24-72 hours, there was aftergrowth of coliform organisms, though not of faecal coliform bacteria or faecal streptococci. This work is still being continued. On Long Island, N.Y., storm run-off is being disposed of successfully by infiltration through the sandy sub-soil to recharge the groundwater resources in the area.

366

PESTICIDES AND OTHER CONTAMINANTS IN RAINFALL AND RUNOFF.

S. R. Weibel, R. B. Weidner, J. M. Cohen, et al.
Amer Water Works Ass J, Vol 58, No 8, pp 1075-84, Aug 1966.
(through Eng Index, p 3185, 1966).

Descriptors: *Storm runoff, Sampling, *Water pollution, Data collections.
Identifiers: *Urban drainage.

Data on rainwater and rural runoff and updated statistics on urban runoff are presented. Rainfall sampling was done in connection with urban stormwater-runoff studies, by Cincinnati Water Research Laboratory. Results of rainfall analyses on pesticides are discussed. Subsequent to collection and analysis of rainfall samples reported, it was found that some materials adhered to stainless steel trays. These materials can be removed by scrubbing with nonphosphate soap and solvent.

367

## THE QUALITY OF RAINFALL RUN-OFF WATER FROM A HOUSING ESTATE.

R. Wilkinson.
Inst Public Health Eng J.
No further identification available.

Descriptors: *Design, *Rainfall intensity, Water pollution, Overflow, Storm runoff.
Identifiers: *Storm sewers, *Urban drainage.

Housing estate of 611 acres, housing density of 5 to 6 houses per acre, est. population of 12,500, separate sewage system with storm system designed on 3/4 in/hr and impervious area of .4. Rain included 131 storms over year period with greatest rain 0.84 in/24 hr. period and most rains of small intensity. Statement made that first flush more polluting than rest of storm, but that certain storms continued stronger than some of the first flushes of other storms. Catchment basin washed clean by first flow of water.

368

## EFFECTS OF CONSTRUCTION ON FLUVIAL SEDIMENT, URBAN AND SUBURBAN AREAS OF MARYLAND.

M. G. Wolman and A. P. Schick.
Water Resources Res, Vol 3, pp 451-464, 1967.
(through Water Pollut Abstr, Vol 41, No 6, p 282, June 1968).

Descriptors: *Water pollution, *Storm runoff, *Sedimentation, Estuaries, *Recreation facilities.
Identifiers: *Urban drainage.

The problem of sediment pollution by run-off from building sites in Maryland is discussed. Sediment yields ranging from 140,000 tons per square mile per year on an open construction site to 1060 tons in an urban area with some development were found. The quantity of sediment from areas under construction is 2-200 times as great as that derived from comparable rural or wooded areas. Details of changes in the stream bed of Oregon Branch caused by sediment from a construction site are given and compared with an unpolluted reach of the stream. Costs arising from sediment pollution of reservoirs, estuaries and channels are discussed and the loss of recreational facilities is mentioned. Measures to control sediment pollution are suggested.

## Section VIII

## SURVEYS, POLICIES, AND LEGISLATION

369

### CHICAGO ACTS TO ATTACK COMBINED SEWER PROBLEM.

Civ Eng, Vol 38, No 8, p 99, Aug 1968.

Descriptors: *Storm runoff, Standards, *Manholes, *Storm drainage.
Identifiers: *Chicago, Ill., *Combined sewers, *Residential sewers, *Urban drainage, Capacity.

The Chicago Metropolitan Sanitary District is planning separate facilities for storm runoff. In the meantime, it has issued an ordinance setting an interim policy for the issuance of permits within a 300-mile area now being served by combined sewers. Provisions of this new ordinance include: only one building drain is required to carry both building wastes and storm water runoff to the combined sewer but municipalities may require separate drains; industries must provide separate services to the control manhole for storm water and industrial wastes; on-site storm facilities for the attenuation of peak flows will be given consideration, but the final determination will be made by the local municipality; and in new construction, downspouting and surface drains to sewers are prohibited unless storm-water capacity has been provided or unless such drainage flows through detention and/or regulating devices.

370

### 200 POLLUTERS GET THE WORD EARLY.

Eng News Rec, p 12, Feb 1, 1968.

Descriptors: *Water pollution control.
Identifiers: *Combined sewers, *Urban drainage, *Sewer separation, Lake Michigan.

Included in a recent list of FWPCA recommendations on pollution in Lake Michigan is a statement that combined sewers be prohibited in all new urban areas and separated in all urban reconstruction projects. The recommendations call for the elimination of pollution from combined sewers in 55 cities by 1977.

371

A REVIEW OF THE LITERATURE OF 1966 ON WASTE WATER AND WATER POLLUTION CONTROL.

U.S. Water Pollution Control Federation.

Water Pollut Contr Fed J, Vol 39, pp 689-749, 867-945, and 1049-1154, 1967.

(through Water Pollut Abstr, Vol 40, No 10, p 449, Oct 1967).

Descriptors: *Water pollution control, *Chemical analysis, *Sewage treatment, *Storm runoff, Estuaries, Standards, Legislation.

In a review of literature published during 1966 on waste treatment and pollution control, subjects dealt with include methods of analysis (including automated chemical techniques); physical and chemical methods of sewage treatment; biological filtration; the activated-sludge process; disinfection of sewage; effects of synthetic detergents on sewage treatment and aquatic organisms; biodegradation of detergents; digestion, treatment, and utilization of sludge; recovery and re-use of sewage and trade waste waters as water supplies; design of sewerage systems and treatment of storm sewage; composting of garbage; treatment of specific types of trade waste waters; treatment, disposal, and polluting effects of radioactive waste waters; biological surveys of polluted waters; polluting effects of sewage and trade waste waters; toxic effects of metals, pesticides, and weedkillers; effects of thermal pollution; effects of pollution on the physiology of fish; bio-assay techniques; estuarine and marine pollution; microbiology of polluted waters; oxygen sag and self-purification; quality standards for streams; effects of pollution on water supplies; pollution of ground water; eutrophication of natural waters; use of systems analysis in managing water resources; and legislation controlling pollution.

372
NINTH ANNUAL REPORT, FOR THE YEAR ENDED DECEMBER 31st 1963. 44 pp.
The Water Research Association.

(Through Water Pollut Abstr, Vol 38, No 11, p 361, Nov 1965).

Descriptors: *Coliforms, Chemical analysis, Turbidity, *Computer programs, *Rainfall-runoff relationships, Groundwater recharge, *Instrumentation, Rain gages, *Sewer hydraulics, Pipes.
Identifiers: *Leak detection.

This report on the work of the Water Research Association contains individual sections on biology (development of synthetic media for use in the coliform test and methods for controlling algae); chemistry (coagulation of water, dewatering of water-works sludge, and methods for the determination of free and combined chlorine, turbidity, chemical oxygen demand (to avoid interference by chlorine) and traces of organic chemicals, pesticides, and herbicides); hydrology (particularly the use of an analogue computer to solve problems connected with the relations between rainfall, run-off, and evaporation, estimation of evaporation from catchment areas, and abstraction and artificial recharge of ground water, and development of instruments for measuring rainfall and stream flow); physics (detection of leaks and properties of pipes); and plant processes (coagulation, demineralization, and fluoridation).

373
HYDRAULICS RESEARCH 1963 AND 1964. THE REPORTS OF THE HYDRAULICS RESEARCH BOARD WITH THE REPORTS OF THE DIRECTOR OF HYDRAULICS RESEARCH.
Dep of Sci & Ind Res and Ministry of Tech.

H. M. Stationery Office, London, 1964 and 1965, 84 pp and 96 pp.

Descriptors: *Hydraulics, *Runoff, *Drainage, *Pipes, *Storm runoff, Estuaries, Model studies, Sewage effluents.
Identifiers: Surface permeability, *Combined sewers.

Hydrological studies reported include: the factors affecting run-off in a permeable (chalk) catchment area and stream flow in an impermeable catchment; the effect of afforestation on the water balance of a catchment area; and lysimeter experiments on factors affecting evapotranspiration and drainage. Studies have continued on the attenuation of flood waves in partly filled pipes, including tests on the mixing of an incoming surge of relatively clean storm sewage with the grossly polluted sewage in a combined sewage system. Studies on estuaries and tidal flow, carried out both in models and in the field, have included the problems of silting, dispersal and recirculation of heated effluents discharged from power stations, and dispersal of sewage effluents from out falls, including flume tests on dispersion in steady turbulent flow.

374
TECHNICAL PROBLEMS OF RIVER AUTHORITIES AND SEWAGE DISPOSAL AUTHORITIES IN LAYING DOWN AND COMPLYING WITH LIMITS OF QUALITY FOR EFFLUENTS MORE RESTRICTIVE THAN THOSE OF THE ROYAL COMMISSION.
Ministry of Housing and Local Government.

H. M. Stationery Office, London, 1966. 20 pp.

Descriptors: *Sewage effluents, *Standards, Dissolved oxygen, *Storm runoff, Sampling.
Identifiers: *Suspended solids, *Great Britain.

This memorandum explains the circumstances under which sewage effluents should be required to reach a standard better than that recommended by the Royal Commission. In deciding the standards to be imposed under particular circumstances, consideration should be given to the probable concentration of dissolved oxygen in the effluent and the possible need for aeration; seasonal variations in requirements; and flows to be treated, including the proportion of storm sewage to be expected. The only standard considered justifiable for discharges of storm sewage is a condition limiting the content of suspended solids, and since this concentration is highly variable it is recommended that these effluents should not be required to conform to a given standard (e.g. 100 mg per liter) all the time, but provision should be made for one or two samples out of every ten, taken on different days, to exceed the limit.

375
FIFTEENTH AND FINAL ANNUAL REPORTS OF THE BRISTOL AVON RIVER BOARD AND THE SEVERN RIVER BOARD FOR THE YEAR ENDED 31st MARCH, 1965.
Bristol Avon River Board; Severn River Board.

46 pp, 2 pl; and 56 pp, 2 pl.
(through Water Pollut Abstr, Vol 39, No 11, p 361, Nov 1966).

Descriptors: *Water pollution control, Sewage treatment, Data Collections, *Standards, *Storm runoff, Sewage effluents
Identifiers: *Suspended solids, Bristol, Great Britain.

These reports each contain information on water resources and the prevention of pollution, including the characteristics of the water and the treatment of sewage and trade waste waters. Tabulated data are included from surveys of the rivers Severn and Avon and their tributaries; and for the Bristol Avon area, the classification of the watercourses is compared with that reported in 1958. In the Severn area, a high standard has been adopted for settled storm sewage, limiting the concentration of suspended solids to 100 p. p. m. based on the average of three consecutive samples. Owing to the excessive amounts of suspended matter often found in effluents from package sewage-treatment plants, the Severn River Board request that land treatment should be provided for these effluents. Recommendations have also been made regarding the design of oil-storage tanks to prevent pollution caused by accidents or misuse.

376
NORTHUMBERLAND AND TYNESIDE RIVER BOARD. ANNUAL REPORTS FOR THE YEARS ENDED THE 31st MARCH, 1962 AND THE 31st MARCH, 1963. 56 pp.

Descriptors: *Water pollution control, Water quality, *Standards, Sewage effluents, *Overflow, *Storm runoff.
Identifiers: *Storage tanks, *Suspended solids, *Great Britain.

These reports each contain a section on the prevention of pollution with information on the quality of river water, instances of pollution and fish mortality, and remedial action, including a summary of new and projected schemes of sewage disposal. Average data obtained in analyses of the more important rivers and streams are appended. Standards for sewage effluents and trade waste waters are outlined. A new standard has been imposed requiring that effluents from stormwater tanks at sewage works shall not contain more than 100 p.p.m. suspended solids. It is not, however, considered practical to impose a standard on the storm-water overflows on sewage systems.

377
ANNUAL REPORTS OF THE SEVERN RIVER BOARD AND THE WYE RIVER BOARD FOR THE YEAR ENDED 31st MARCH, 1964.
Severn River Board; Wye River Board.

77 pp, 1 plate; and 60 pp.
(through Water Pollut Abstr, Vol 39, No 5, P 150, May 1966).

Descriptors: *Water pollution, *Storm runoff, *Standards, Biochemical oxygen demand, Discharge (water), Estuaries.
Identifiers: *Suspended solids, Great Britain.

Both these reports contain sections on water resources for parts of the catchments of the rivers Bewdley and Avon. Abstraction of water for irrigation is increasing and the importance of providing bank storage has been emphasized. Results of surveys of the rivers Severn and Avon, certain of their tributaries, and tidal waters are given and discussed in detail in relation to the various sources of pollution and prospects for future improvements. It is planned to make a complete survey of the rivers Wye and Lugg each month, with less frequent sampling of other tributaries, and the first two complete surveys are reported and discussed. It is considered that effluents discharged to the Wye estuary should conform to the normal standards for a grade-one effluent, in view of the character of the river and the mortality of salmon in the tidal reaches nearly every summer. A measure of control has also been extended to estuaries in the Severn River Board area, and an appreciable departure from the normal working standards was possible when determining the required standards for partially-treated sewage and sewage-works effluents. Basic standards for the discharge of effluents to watercourses are also outlined, including those for pre-1951 discharges. In the case of farm waste waters, allowance is made for the self-purification which may take place in the ditch or stream to which the effluent is discharged. With regard to partially-treated storm sewage, the Severn River Board have abandoned the standard limiting the BOD and, apart from specific standards for toxic materials, the strength and quality of these discharges are now controlled by a limit of 100 p.p.m. on the concentration of suspended solids. This standard also applies in the Wye River Board area where the concentration of sulphide is also limited to 1 p.p.m., as hydrogen sulphide. The standard imposed on the discharge of chlorinated water from a swimming pool limited the concentration of chlorine to 0-5 p.p.m., as free chlorine, and also limited the rate of discharge to ensure that there was sufficient dilution available in the receiving stream to avoid the risk of toxicity to fish. Alterations in the treatment and discharge of sewage and trade waste waters are outlined, together with proposals for new treatment plants.

378

ANNUAL REPORTS OF THE SEVERN RIVER BOARD AND THE WYE RIVER BOARD FOR THE YEAR ENDED 31st MARCH, 1963. 70pp.

Descriptors: *Water pollution control, *Standards, Sewage effluents, *Biochemical oxygen demand, *Storm runoff, *Surface runoff, *Overflow. Identifiers: *Combined sewers, *Capacity, *Great Britain.

These reports each contain sections on water resources, fisheries, and prevention of pollution. The basic standards for effluents are summarized; they have remained unaltered except that, following a decision by the Ministry of Housing and Local Government, no limitation is now imposed on the B. O. D. of discharges of partially-treated sewage or storm water. Progress in the construction of works to alleviate pollution of the Severn river system has been satisfactory but in many cases full advantage of the new sewage works cannot be taken in storm time until improvements to the main sewerage system have also been carried out. A number of sewage authorities have accepted the policy of the Severn River Board for reducing the storm product in combined sewers by the selective elimination of surface water, and the enlargement of main sewer capacities will permit closure of certain overflows. New storm overflows are not permitted except in exceptional circumstances.

379
DELAWARE ESTUARY COMPREHENSIVE STUDY PRELIMINARY REPORT AND FINDINGS.
Fed Water Pollut Control Admin, Phila Pa.

July 1966, 113 pp, figs.

Descriptors: *Estuaries, Water quality, *Storm runoff, Overflow, *Water pollution, "Sampling, *Biochemical oxygen demand.
Identifiers: *Combined sewers.

The Delaware river estuary - particularly the segment between Trenton and the Pennsylvania-Delaware state line below Wilmington - was studied from the points of view of municipal and industrial waste discharges, water quality and its improvement by five specific alternative objective sets, water use, costs and benefits of projected imporvements, and guidelines for implementation. Stormwater overflow discharges are considered esthetically objectionable, although in comparison with other waste input it does not constitute a large source of oxygen-demanding pollution of the estuary. A continuation of the reported stormwater sampling program is urged, and a demonstration project to counteract undesirable effects of combined sewer overflow is recommended.

380
DRAINAGE PROBLEMS IN AN AREA CHANGING FROM RURAL TO URBAN.

Robert W. Brannan.
Public Works, Vol 93, p 10, 1962.

Descriptors: *Land use, Drainage systems.
Identifiers: *Urban drainage.

Gives some discussion on economic losses due to urbanization and poor drainage for Lucas County, Ohio. Also regulatory control methods that should be considered.

381
NATURE AND SCOPE OF SURFACE DRAINAGE IN EASTERN UNITED STATES AND CANADA.

E. W. Gain
Amer Soc Agr Eng, Trans, Vol 7, No 2, pp 167-9, 1964.
(through Eng Index, p 460, 1964).

Descriptors: *Surface drainage, *Design.
Identifiers: Interceptor sewers, United States, Canada.

Review of basic surface-drainage systems now in use includes "random", "bedding","regular" or "parallel ditch", "interception", and"diversion" systems.

382
NEW YORK STATE MUNICIPAL WATER AND SEWAGE.

R. D. Hennigan
Water Sewage Works, Vol 110, No 12, pp 448-52, Dec 1963.

Descriptors: *Planning, Construction, *Legislation, Grants.
Identifiers: *Storm sewers, Urban drainage, New York.

The need for a unified approach to the planning, construction, and operation of all water utility services is stressed. In particular, water service, sewer service, and storm drainage projects should be planned on an integrated basis. New York State laws and constitutional changes have been designed to encourage an integrated approach to the planning of water and sewage works. Recent legislation relating to such planning is described. One provision would enable municipalities to obtain 100% support for approved comprehensive sewer and water studies. The author observes that "counties are increasingly becoming the focus for providing area-wide water and sewer facilities." A brief listing of sources of fiscal aid is included.

383
TRENDS IN FINANCIAL SUPPORT FOR WATER POLLUTION CONTROL.
Water Resources Res Inst, Consol U of North Carolina, Raleigh, N.C.
David H. Howells
ASCE Proc, J. Sanit Eng Div, Vol 93, No SA3, pp 1-13, June 1967.

Descriptors: *Water pollution control, Construction, *Grants, *Legislation.
Identifiers: *Combined sewers.

The trend in Federal support of municipal waste-treatment construction is toward larger annual appropriations with higher levels of support for states providing matching funds. States should enact parallel grant-in-aid legislation to take full advantage of Federal aid in the future and maintain an influential position in water-pollution control. Rapid movement toward financial assistance for industrial waste treatment is not anticipated unless the current study by the Secretary of the Interior should add to the momentum. Effluent charges are considered unlikely if industry responds favorably to its responsibilities for water-pollution control. The Clean Waters Restoration Act of 1966 authorized 75% grants to public bodies for projects concerned with improved pollution control from combined sewers.

384
INTERPRETING THE 1951 RIVERS POLLUTION PREVENTION ACT.

W. F. Lester.
Munic Eng Sanit Rec, Vol 131, pp 186-7, 1954.

Descriptors: Standards, Sewage effluents, *Water pollution, *Overflow, *Storm runoff, *Legislation.
Identifiers: *Rivers (Prevention of Pollution) Act 1951.

The author discusses the implementation of the Rivers (Prevention of Pollution) Act 1951. Details are given of the standards recommended by the Royal Comm. on Sewage Disposal for effluents discharged to surface waters and demands are made for more stringent standards. The problem of dealing with storm water overflows from sewage works or from separate sewerage systems is discussed with reference to the work of the River Boards in making by-laws.

385
CONTROL OF SEWER USAGE AT DETROIT, MICHIGAN.

C. L. Palmer.
Sewage Works J, Vol 18, No 6, pp 1127-9, Nov 1946.

Descriptors: *Standards, Sewage treatment, *Discharge (water), *Storm runoff, Sewers.
Identifiers: *Detroit, Mich.

Discussion of "Standards and Regulations" in Detroit, that are to apply to point where industrial or commercial type wastes are discharged into public sewer; data on sewage treatment facilities and discharge of storm water to Detroit and Rouge Rivers.

386
WATER POLLUTION CONTROL FEDERAL AID PROGRAMS.
Div. Water Supply & Pollut Contr, HEW, Washington, D.C.
Paul W. Reed.
Paper presented at the 12th Annual Wastes Engng Conf, Univ. of Minn, Minneapolis, Minn, Dec 10, 1965. 15 p.

Descriptors: *Water pollution control, *Construction, *Grants, *Legislation.

The FWPCA is described with special emphasis on the construction grant programs. Surveys of municipal waste treatment needs are described. The Water Quality Act of 1965 is outlined. Public Health Service studies on water pollution control are summarized as well as related Federal programs.

387
STANDARDS AND TECHNICAL SPECIFICATIONS FOR PLANNING SEWERS IN INHABITED LOCALITIES.

A. N. Shevkun.
Vodosn Sanit Tekh, No 3, pp 1-5, 1957.

Descriptors: *Standards, *Sewers, Planning, Design.
Identifiers: *Combined sewers, *Russia.

The author reviews recent Russian regulations concerning the design of separate and combined sewerage systems and sewage works.

388
SEWAGE DISPOSAL.
L. J. A. Stow.
Surv, Vol 106, p 567, 1947.

Descriptors: *Water Pollution, *Standards, *Storm runoff, Sewage effluents.
Identifiers: *Great Britain.

The author discusses the existing state of river pollution in Great Britain with special reference to the need for standards for sewage works effluents, and for more complete treatment of all storm water.

# Section IX

# TREATMENT METHODS

206-A

389
FINE SCREENS FOR COMBINED SEWAGE.

Amer City, p 42, Dec, 1967.

Descriptors: *Biochemical oxygen demand, *Overflow, sewage treatment.
Identifiers: *Combined sewers, *Suspended solids.

A study to determine the feasibility, effectiveness and economics of providing primary treatments to reduce BOD and suspended solids from overflow of combined sewers is outlined. Combined sewage and overflow will pass through two fine-mesh vibrating screens each 7 ft. in diameter and one 60 inch horizontal screen.

390
TESTS CHEMICAL TREATMENT OF STORM OVERFLOW.

Amer City, p 36, Nov, 1967.

Descriptors: *Sewage treatment, *Storm runoff, *Overflow, Water pollution, *Equipment.
Identifiers: *Storm sewers, *Polymers, *Suspended solids.

Work by Dow Chem. Co. under an FWPCA contract to determine the effectiveness of chemical treatment of storm-sewer overflow is described. Objectives of the study are: to detail the sequence of events that occurs during and immediately after storms, particularly the volume and pollutional content of the storm water; to determine the value of organic flocculants for the removal of suspended material from storm-sewer overflow; to study the effectiveness of several types of disinfectants in the waste flow; and to design equipment that will make effective use of chemicals. The polymers used are Purifloc flocculants.

391
$5,729,103 AWARD FOR WATER POLLUTION RESEARCH.

APWA Reporter, Mar, 1968.

Descriptors: *Water pollution control, *Overflow, *Storm runoff, Sewage treatment.
Identifiers: *Combined sewers, *Storage tanks, Jamaica Bay, NY.

The FWPCA recently awarded several contracts concerned with methods to control pollution from overflows of combined sewers during storms, including an evaluation of a treatment plant for combined sewer outflows into Jamaica Bay, and construction and evaluation of a 2 million gallon combined sewage treatment and storage facility in New Hampshire. Demonstration contracts to find solutions to the combined sewer problem were awarded and include: a facility to treat wastes by microscreening, and facilities to demonstrate off-shore, underwater storage of storm water overflow, from combined sewers.

392
TO RESTORE LAKE ERIE BEACHES.

ASCE, Newsletter Sanit Eng Div, p 6, May, 1968.

Descriptors: *Recreation facilities, *Water pollution control, *Overflow, Flow control, *Chlorination, Discharge (water).
Identifiers: *Combined sewers, *Cleveland, Ohio, *Lake Erie, *Interceptor sewers, Capacity, *Polymers, *Sewer flushing.

Cleveland, Ohio is attempting to restore some of its Lake Erie beaches polluted by overflows of combined storm and sanitary sewers. Methods under investigation are: 1) the use of polymers to reduce overflows from the Edgewater sewer by increasing the flow-carrying capacity of the Westerly interceptor sewer; 2) hypochlorination of the major overflows and creek waters entering Lake Erie; 3) flushing sewers during dry weather to reduce the discharge of solids when it rains; 4) screening of overflows and streams.

393
A PLAN TO HELP LAKE ERIE.

ASCE, Newsletter Sanit Eng Div, p 5, Jan, 1967.

Descriptors: *Overflow, *Construction, *Sewage lagoons, sewage treatment.
Identifiers: *Cleveland, Ohio, *Storage tanks, *Combined sewers, *Lake Erie.

The feasibility of building a large waste-water holding and treatment reservoir in Lake Erie for combined-sewer overflows in Cleveland is being studied. The possibility of building a deep detention facility off the shore of Lake Erie is being investigated because of the high cost of acquiring valuable lakefront land there. Construction techniques will be analyzed and the best methods of operation to assure flexibility of use and efficiency of treatment will be recommended. If this proves to be feasible, the lagoon may provide further treatment of the wastes from Cleveland's Easterly secondary-treatment plant and flows from storm sewers in this section of the city.

394

FEDERAL GRANT TO HELP RESTORE CLEVELAND BEACHES.

Civ Eng, Vol 38, No 6, p 85, June, 1968.

Descriptors: *Recreation facilities, *Overflow, Flow control, *Chlorination, Storm runoff, *Water pollution control, Discharge (water). Identifiers: *Combined sewers, *Cleveland, Ohio, *Polymers, *Lake Erie, *Sewer flushing, *Interceptor sewers, Capacity.

Cleveland, Ohio has received a grant to restore beaches polluted largely by overflows of combined sewers and to expand recreational opportunities for the area. Control and treatment methods to be used in this project include: experimental use of polymers to reduce overflows from the combined sewers by increasing the flow-carrying capacity of interceptor sewers; hypochlorination of the major overflows and creek water entering Lake Erie; implementation of a sewer-flushing program during dry weather to reduce the discharge of solids when it rains; and screening of overflows and streams.

395

MILWAUKEE SEEKS TO SOLVE POLLUTION PROBLEM.

Civ Eng, Vol 37, No 9, p 79, Sept, 1967.

Descriptors: *Storm runoff, *Overflow, *Chlorination, *Chemical analysis. Identifiers: *Milwaukee, Wis., *Storage tanks, *Combined sewers, *Bacteriological sampling.

Milwaukee will construct a huge underground tank to catch rainstorm overflow from the combined sanitary-storm sewer system. The demonstration tank will be 170 ft. long, 130 ft. wide, and 30 ft. deep, and will hold 3.9 million gallons. The tank is being designed to catch the runoff, purify it with chlorine, or hold it until the storm ends. Then the runoff will gradually be drained back into the combined sewer system, which flows to the treatment plant. In addition to this demonstration project, the quality and quantity of the combined flow, including a physical, chemical and bacteriological analysis of the combined waste, will be made in an effort to determine when the sewers overflow or for how long.

396
NEW ORLEANS HAS GRANT TO TREAT STORM WATER.

Civ Eng, Vol 37, No. 3, p 103, Mar, 1967.

Descriptors: *Storm runoff, Recreation facilities, *Water pollution, *Overflow, *Chlorination.
Identifiers: Grants, *Storm sewers, *New Orleans, La., *Urban drainage.

Lake Pontchartrain beaches now have to be closed after heavy summer rains when storm water, with a high bacteria count, is pumped from the canals in New Orleans into the lake. Although New Orleans has separate storm-water and sewer systems, some overflow from the sewers into the canals carrying rain water does occur. In addition, the canal waters are contaminated by dirt washed off the streets during rains. A demonstration project is being initiated to study the injection of chlorine into storm waters in four open canals discharging into the lake. At one of the chlorine-injection stations a special concrete chamber, 1,300 ft. long, 85 ft. wide, and 14 ft. deep, will be built in a canal to assure that the chlorine will be adequately mixed with the storm waters. The project also involves the construction of a chlorine-blending plant to avoid the potential hazard of using the disinfectant in its gaseous form.

397
IMPROVEMENTS TO SEWAGE TREATMENT AT BATH.

Civ Eng Public Works Rev, Vol 63, No 738, p 70, Jan, 1968.

Descriptors: *Sewage treatment, *Pumping, *Storm runoff.
Identifiers: Capacity.

Modifications to the City of Bath's sewage treatment system include the provision of new storm sewage treatment plant adjacent to their pumping station at Twerton, the plant now being designed to deal with some 17 m.g.d. under storm conditions, while a further 10.5 m.g.d. will be pumped 5 miles through a 30 in. rising main to the main treatment plant at Saltford. In order to connect the new pumping capacity, a temporary pumping was required to handle the full flow of sewage, so that the wet well could be isolated and work on connecting the pipe work be carried out. For this purpose, the inlet chamber, measuring 6 ft. x 5 ft. was converted to a sump to receive the full flow of sewage and 5 Sykes 6 in. Univac pumps, working on a total suction lift of 25 ft. were installed. Normal peak mid-day and evening flows handled by the pumps are of the order of 250,000 gal/hr. With the wet well isolated, the 3 ft. thick dividing wall of the well was cut through using the ladder drilling method with holes at 4 in. centers being cut down by paving breakers to give an opening of some 4 ft. 6 in. square section. Old pipe sections which had to be removed were maneuvered through this opening by chain block and tackle before the new 24 in. dia. suction branches could be replaced.

398

ELMBRIDGE WATER POLLUTION CONTROL WORKS.

Civ Eng Public Works Rev, Vol 62, No 734, p 997, Sept, 1967.

Descriptors: *Storm runoff, *Overflow, *Sewage treatment, *Sedimentation, *Sewage sludge, Equipment.

The new sewage disposal works at Cranleigh will deal with sewage flows up to 3 x D.W.F. and all storm flows will be treated in the old works which have been modified. At the storm overflow chamber, flows in excess of 3 x D.W.F. are overflowed to the old works for treatment in the sedimentation tanks, biological purification on four filters and secondary settlement in the humus tanks before discharge to the Cobblers Brook. In order to deal with these storm water flows, the first of the three sedimentation tanks has been equipped with a sludge scraping mechanism and the other two tanks have a ridged floor formed by precast concrete units to facilitate the removal of the sludge settling in these tanks. The old filters have had new revolving distributors fitted and arrangements have been made to trickle feed these filters with settled sewage during dry weather. In this way, the micro-organisms which must be present to effect biological purification will be kept alive and the filters ready to treat the excess flows in wet weather.

399
TUNNEL WILL STORE STORM-RUNOFF.

Eng News Rec, Vol 179, No 22, p 32, Nov, 30, 1967.
(through Eng Index, p 163, April, 1968).

Descriptors: *Overflow, Storm runoff, Treatment, Pumping, Tunnels.
Identifiers: *Combined sewers, Chicago, Ill.

Chicago's Dept of Public Works tunnel is designed to hold excess flow from combined storm and sanitary sewer system in area during heavy rains. When rain runoff stops, pumps in tunnel will put sewage back into existing system leading to treatment plants. Schematic drawings of tunnel and water diversion from combined line to tunnel.

400
PLANT WILL HALT STORM POLLUTION.

Eng News Rec, Vol 178, No 7, p 16, 1967.
(through Water Pollut Abstr, Vol 41, No 4, p 173, April 1968).

Descriptors: *Overflow, Sewage treatment, Solid wastes.
Identifiers: Storm sewers.

A description is given of the proposed system of centrifuging and air injection to be installed at the sewage works of Fort Smith, Ark., to remove solids from storm-sewage overflows which by-pass the works. A study will also be made of the system as part of the normal treatment process, functioning between the bar screens and the primary sedimentation tanks.

401
SEATTLE SEES VICTORY IN ITS BATTLE AGAINST POLLUTION.

Eng News Rec, Vol 174, No 23, pp 44-46 and 51, 1965.
(through Water Pollut Abstr, Vol 39, No 11, pp 377-8, Nov, 1966).

Descriptors: *Overflow, Sewage treatment.
Identifiers: *Storage tanks, Storm sewers.

The comprehensive sewage-disposal facilities planned for Seattle, Wash., to reduce pollution of lake Washington and coastal waters of Puget Sound are outlined; the Renton and West Point treatment plants are now in operation. Some pollution is still likely to occur as a result of overflows of storm sewage; one proposal to reduce this is construction of holding tanks near lake Washington.

402

### CITY PLANS TO TREAT STORM WATER.

Eng News Rec, Vol 172, p 22, May 28, 1964.

Descriptors: *Storm runoff, *Chlorination, *Overflow, Recreation facilities, Design, Estuaries.
Identifiers: *Storage tanks, *Storm sewers, Capacity, *New York, N.Y.

Describes the 'Marginal Pollution Control Program' for New York City in and around Jamaica Bay, Eastchester Bay and the Upper East River. Large detention tanks are being constructed with chlorination facilities at the storm sewer overflows. Tanks are designed to capture an estimated 25 of 40 summer storms with 15 overflowing. The initial phase of construction for Jamaica Bay will include 4 storm water detention tanks serving 12,663 acres. The above program is designed for protection of the cities bathing beaches.

403

### UNDERWATER STORAGE OF STORM OVERFLOW.

Environ Sci Technol, Vol 2, No 9, p 668, Sept, 1968.

Descriptors: *Overflow, *Storm runoff, Design, *Flowmeters, Sewage sludge, Pumping.
Identifiers: *Combined sewers, *Storage tanks, *Washington, D.C., *Interceptor sewers, Suspended solids.

The feasibility of storing overflow of combined sewers in inflatable tanks anchored to the bottom of a river bed is being studied by a pilot project in the Anacostia River in Washington, D.C. The project is intended to demonstrate that this approach can capture, handle, store, and return overflow to the interceptor sewer without the overflow ever touching the river. The tanks are made of synthetic rubber impregnated with nylon fabric. They measure 120 x 20 feet, and stand between 6 and 7 feet high when inflated. In operation, the system will work this way: storm overflow passes through a Parshall flume where the volume is measured and recorded. At a predetermined level, a butterfly opens to allow influent to enter a grit chamber, where oils and grease float to the top and are skimmed off. The flow passes through a comminutor which shreds all solids down to 3/8 inch. The flow then moves by gravity to the storage tanks. When it is ready to be pumped back to the interceptor, compressed air is used to prevent sludge buildup.

404
UNDERWATER TANKS WILL STORE RUN-OFF WATER.

Environ Sci Technol, Vol 2, No 3, p 169, Mar, 1968.

Descriptors: *Storm runoff, *Overflow, Design.
Identifiers: *Storage tanks.

Underwater tanks to store excess sewage and run-off waters during overflow conditions will be designed, constructed, and operated by Melpar, Inc. The stored water will be returned to the municipal treatment plant when conditions are more favorable. The tank will be located on the river bottom several hundred feet from shore and will not be a hindrance to navigation.

405
NEW ORLEANS TRYING DISINFECTION OF STORM-SEWER DISCHARGES.

Public Works, Vol 98, No. 3, p 139, 1967.
(through Water Pollut Abstr, Vol 41, No 4, p 171, April, 1968).

Descriptors: *Storm runoff, *Chlorination, Recreation facilities.
Identifiers: New Orleans, La., Storm sewers.

Pollution of Lake Pontchartrain through the discharge of storm sewage from New Orleans into canals, has occurred, leading to closure of the beaches after heavy rains when the canal contents are pumped into the lake. To remedy this, it is planned to chlorinate the storm sewage in the canals.

406
MILL GREEN SEWAGE DISPOSAL WORKS EXTENDED.

Surv Munic City Eng, Vol 129, No 3912, pp 27-28, 31, 1967.
(through Water Pollut Abstr, Vol 41, No 5, p 216, May, 1968).

Descriptors: *Storm runoff, Treatment.
Identifiers: Storage tanks.

An illustrated description is given of recent extensions to the Mill Green sewage works of Hatfield R.D.C., Herts., which serve the northern part of Hatfield and neighbouring villages. The new works, designed for a flow of 1 m.g.d., include increased pumping capacity, additional percolating filters and 3 microstrainers for tertiary treatment of humus-tank effluent before discharge to the river Lee. Storm sewage is returned for full treatment after storage. After two-stage digestion, sludge is dried on beds.

407

WORTHING'S £500,000 SCHEME OF DRAINAGE IMPROVEMENTS.

Surv, Vol 121, pp 1069-1070, 1962.
(through Water Pollut Abstr, Vol 37, No 1, p 15, Jan, 1964).

Descriptors: *Storm runoff.
Identifiers: *Storage tanks.

Improvements are being made at the overloaded sewage works of Worthing, Sussex, where previously sewage was discharged to sea after screening and chlorination. At the West Worthing works, which will treat a dry-weather flow of 1.31 m.g.d., the screens are being replaced by comminutors, and sedimentation tanks and new storm-water tanks are being constructed. At the East Worthing works (which will have a dry-weather flow of 3.14 m.g.d.) improvements include the enlargement of the existing pumping station, installation of a comminutor, conversion of the existing tidal storage tanks to storm-water tanks, and construction of new storage tanks. The effluents will be discharged over a tidal period of 8-1/2 hours. Sludge from both works will be combined with refuse and sold as compost.

408

STRATFORD-UPON-AVON SEWAGE WORKS.

Water Pollut Contr, London, Vol 66, pp 268-269, 1967.
(through Water Pollut Abstr, Vol 41, No 6, p 263, June 1968).

Descriptors: *Storm runoff, Treatment, Land use.

A description is given of the new Milcote sewage works of Stratford, Warwickshire, which provide complete treatment for a dry-weather flow of 1.55 m.g.d. by biological filtration with recirculation of effluent. Sludge is digested and disposed of on land; drying beds are available for dewatering excess sludge. About 1 acre of underdrained land is also available for treatment of storm sewage or for further treatment of final effluent if necessary.

409
WINDSOR STARTS POLLUTION CLEAN-UP.

Water Pollut Contr, Ontario, Vol 104, No 5, pp 23-27, 1966.
(through Water Pollut Abstr, Vol 40, No 3, p 124, Mar, 1967).

Descriptors: *Storm runoff, Sewage effluents, Chlorination.

Treatment facilities provided at the Little River sewage works at Riverside, Windsor, Ontario, are outlined and illustrated. The plant, which serves Riverside and Sandwich East, has a capacity of 4 m.g.d., with space available for future expansion; it provides complete treatment by the activated-sludge process. Excess storm sewage and final effluent are chlorinated before discharge to the Little River, while crude primary and excess activated sludge are conditioned with ferric chloride and lime, dewatered on an automatically-controlled vacuum filter, and used as land-fill.

410
CITY OF MILWAUKEE.

Water Wastes Eng, p 118.
No further identification available.

Descriptors: *Overflow, *Storm runoff, *Chlorination.
Identifiers: *Combined sewers, *Storage tanks, Milwaukee, Wis.

Milwaukee is constructing an underground concrete tank to catch rainstorm overflow from the combined sewer system. The demonstration tank will be 170 ft. long, 130 ft. wide and 30 ft. deep and will hold 3,900,000 gal. The tank will be designed to catch the run-off, purify it with chlorine or hold it until the storm ends. Then it will gradually drain the run-off back into the combined sewer system, which flows to the sewage treatment plant.

411
TREATMENT OF OVERFLOWS FROM COMBINED SEWERAGE SYSTEMS BY USE OF STORM WATER STORAGE AND CHLORINATION.

New Hampshire Water Pollution Commission Staff Report No. 40, March 1959.

Descriptors: *Overflow, *Storm runoff, *Chlorination, Water quality, Recreation facilities.
Identifiers: *Combined sewers, *Storage tanks.

A study of a procedure to treat enough of the storm water overflow from an adequate combined system to achieve B-1 quality in a receiving water nearly 100% of the summer bathing season. Assumptions and procedure are detailed.

412
BACTERIAL REDUCTIONS IN THE CHLORINATION OF SEWAGE--EFFECT OF AGITATION.

New Hampshire Water Pollution Commission Report No 3, Staff Report No 42, March, 1960.

Descriptors: *Chlorination, *Sewage effluents, *Coliforms, Sewage treatment.

Report covers three studies on the bacteriological acceptability of effluents which have been chlorinated with doses of 30 to 40 ppm with gentle stirring after comminution. Study 1: Determined if there exists a practical level of chlorination of raw sewage that 99 percent of time with 15 minute chlorine contact and without settling can be relied upon to produce ultimate coliform bacterial counts in the effluent not to exceed 240/100 ml even when such effluent is subsequently subjected to rigorous breakup of particulate matter. Finding -- at practical chlorine dose levels of 40 ppm or less simple chlorination of unsettled raw sewage cannot be relied upon.

413
SYSTEM STUDY, DESIGN, AND EVALUATION OF THE LOCAL STORAGE, TREATMENT AND REUSE OF STORM WATER.
Hittman Associates, Inc.

Final Report - Vol 1, Contract No 14-12-20 with the Federal Water Pollution Control Administration August 1967. 5 pp.

Descriptors: *Storm runoff, *Treatment, *Water reuse, Sampling, Computer programs.
Identifiers: Columbia, Md., *Storage tanks.

An $850,000 two-year program is suggested for the collection of stormwater runoff in three small storage basins and pretreatment units in the new city development of Columbia, Md., the treatment of this runoff to remove pollutants, and its further treatment for potable reuse. A packaged water treatment plant would be used to determine the technical and economic feasibility of such treatment. Gaging and sampling stations, and a connection to the public water system, are included in the plan. A computer-generated cost-benefit analysis was used to determine such facets as optional size of storage reservoirs and optional system configuration. A "Study of Reuse of Storm Water", by Whitman, Requardt & Associates, indicating various consumptive (e.g., toilet flushing) and non-consumptive (e.g.,fire protection) re-uses, forms part of the Appendix.

414

THE CONSTRUCTION OF RETARDING BASINS FOR THE DRAINAGE OF MOTORWAYS.

G.W. Annen.
Gas Wasserfach, Vol 108, pp 46-48, 1967.
(through Water Pollut Abstr, Vol 40, No 7, p 291, July 1967).

Descriptors: Runoff, *Drainage, *Highways, Pollution abatement.
Identifiers: Retarding basins.

A detailed description is given of the design and operation of retarding basins, which have been installed along the newly built motorway south of Dortmund, Germany. These basins are designed to slow down the run-off, separating mechanically the insoluble polluting substances, particularly oils, and thus protecting the receiving waters.

415

PROTECTING THE POTOMAC AT WASHINGTON.

D.V. Auld.
Water Pollut Contr Fed J, Vol 37, pp 275-291, 1965.
(through Water Pollut Abstr, Vol 38, No 9, p 305, Sept, 1965).

Descriptors: *Water pollution control, Water quality, *Chlorination, *Storm runoff, Sewers, Estuaries.
Identifiers: *Combined sewers, *Sewer separation, *Potomac River, *Storage tanks.

To reduce pollution of the Potomac river in the Washington metropolitan area, several counties, cities and towns have formed an informal organization that has adopted water quality objectives for 63 miles of the river, agreed that there should be neither treated nor untreated waste discharges for some 38 miles above the head of tide-water, and established a Regional Sanitary Advisory Board which has developed a comprehensive plan for sewage disposal. As part of this regional effort, the District of Columbia is providing sewerage facilities for much of the surrounding territory, including the new Dulles International Airport in Virginia. The sewage works have been expanded to provide secondary treatment by the high-rate activated-sludge process, and it is planned to provide preliminary tanks and chlorination facilities for storm flows in excess of those receiving complete treatment. The new sewerage facilities are on the separate system, and work has already begun on converting the older parts of the system from the combined to the separate type.

416
CHICAGO MSD PROGRESS REPORT ON CHLORINATION.
The Metropolitan Sanitary District of Greater Chicago, Chicago, Ill.
Vinton Bacon.
Water Sewage Works, pp 350-351, Sept, 1967.

Descriptors: *Chlorination, Sewage treatment, *Construction costs.
Identifiers: Capacity, *Chicago, Ill.

It has been possible to complete chlorination facilities for the North Side Sewage Treatment Works 1-1/2 years ahead of schedule, by utilizing the effluent conduit and the North Shore Channel for the contact basins, thus obviating long and costly construction. The cost of this project was a dramatically low $162 per mgd capacity, in contrast to $8,380 per mgd capacity for other plants. At the rated capacity of 300 mgd, a 9-minute detention is achieved in the effluent conduit. Chlorine dosages of 1.8 mg/l are being used for initial operations.

417
CHICAGO METRO SANITARY DISTRICT MAKES NO LITTLE PLANS.

V.W. Bacon and F.E. Dalton.
Public Works, Vol 97, No 11, pp 66-70, 140, 142, 1966.
(through Water Pollut Abstr, Vol 41, No 1, p 22, Jan 1968).

Descriptors: *Water pollution control, Sewage sludge, *Storm runoff, *Overflow, *Chlorination, Sewage treatment.
Identifiers: *Combined sewers, *Storage tanks, *Chicago, Ill., Sewer separation, *Rapid filter.

Because of increased demands on treatment plants and higher environmental standards, various solutions are considered for easing the pollution problem in the Chicago area, including the use of long transmission lines to discharge digested sludge to large areas of marginal agricultural soil and to coal strip mines. Also considered is the underground storage of contaminated storm-sewage overflows from combined sewers; storage would be in a system of tunnels and large chambers excavated in solid rock deep under the city, and the sewage would be pumped to the surface for treatment after storms, a more economical solution than the provision of separate sewers. As a temporary solution the District is experimenting with the chlorination of storm-sewage overflows. A brief report is given on the need for tertiary treatment; a 2 m.g.d. plant will be installed as an experiment at the District's Hanover Park plant to provide tertiary treatment by coagulation, chlorination, rapid sand filtration, and final aeration.

418

USE OF STORM RUNOFF FOR ARTIFICIAL RECHARGE.

J. E. Berend, M. Rebhun, and Y. Kahana.
Amer Soc Agr Eng, Trans, Vol 10, No 5, pp 678-84, 1967. 15 ref.
(through Eng Index, p 280, Aug 1968).

Descriptors: *Storm runoff, *Water quality, *Instrumentation.
Identifiers: Surface permeability, Israel.

Utilization of flood water both as source of additional supply and as means of introducing low-salinity water into water supply system in Israel was investigated. Studies were carried out on development of adequate research methods and of suitable instrumentation, and in such manner as to make them also useful in planning reclamation of sewage effluents. Studies of quality of waters and their response to treatment, infiltration capacity of spreading grounds and analysis of infiltration phenomena and process of clogging, its prevention and corrective measures are discussed.

419

EXPERIMENTS IN WATER SPREADING AT NEWARK, DELAWARE.

D. H. Boggess, and D. R. Rima.
U.S. Geol Surv Water Supply Pap 1594-B, U.S. Govt Printing Office, Washington, D. C., 1962.

Descriptors: *Storm runoff, *Groundwater recharge.
Identifiers: Surface permeability, Newark, Del.

Results are given of further experiments at Newark, Del., on the possibility of using excess storm run-off to recharge ground water. Although nearly 500,000 gal of water were spread in an infiltration ditch near the municipal well field and allowed to seep into the subsurface, there was no indication that any appreciable amount of water reached the producing aquifer. Instead, a perched zone of saturation was created by the presence of an impermeable or slightly permeable bed above the water table. This layer barred the downward movement of water so effectively that in less than one day the apex of the perched zone rose about 10 ft to the level of the bottom of the infiltration ditch, and as more water was added the mound of saturation spread laterally. From these experiments it was concluded that the principal aquifer at Newark would not be benefited by spreading water in shallow infiltration ditches or basins, although the absorptive capacity of the unsaturated materials which occur at shallow depth is sufficient to permit of the disposal of large volumes of storm water. However, the well field might be recharged by other methods; one possible solution would be a shallow basin to store excess storm water both of the land surface and in the permeable beds at shallow depth, and within this basin recharge shafts could be constructed to expose the top of the producing aquifer and allow water from the surface and from the sand and gravel bed to infiltrate through the shaft and into the aquifer below.

420

## THE ST. JOSEPH, MISSOURI WATER POLLUTION CONTROL PROGRAMME.

R.L. Brown, and W.R. Condon.
Water Pollut Contr Fed J, Vol 39, pp 1374-1380, 1967.
(through Water Pollut Abstr, Vol 40, No 12, p 553, Dec 1967).

Descriptors: *Water pollution control, *Storm runoff, *Sewage treatment, Sedimentation, Sewage sludge, Maintenance.
Identifiers: *Combined sewers, St. Joseph, Mo.

To reduce pollution of the Missouri river, a sewage works is being constructed at St. Joseph, Mo., to provide treatment for combined sewage and storm water by aerated grit removal, sedimentation, and sludge digestion. Digested sludge will be dewatered by vacuum filtration, but provision has also been made for dewatering on sand beds or for disposal of liquid sludge on farmland. The operation and maintenance of the sewerage system are described.

421

## CHLORINATION OF MIXED SEWAGE AND STORM WATER.

T.R. Camp
ASCE Proc, J Sanit Eng Div, Vol 87, No SA 1, 1961.

Descriptors: *Chlorination, *Storm runoff, Outlets, Sewage treatment, *Biochemical oxygen demand, *Pathogenic bacteria.
Identifiers: *Suspended solids, *Combined sewers.

The author deplores the present tendency to concentrate on primary treatment of sewage to reduce the B.O.D. and the concentration of suspended solids, while overlooking the need for destruction of pathogenic bacteria and viruses. In older communities with combined sewerage systems about 3 per cent of the sanitary sewage is discharged with storm water through storm-water outfalls, and this should also receive treatment to remove bacteria. The author describes experiments carried out on the chlorination of sewage alone and in admixture with storm water. The results indicate that such treatment is effective. The amount of chlorine required for disinfection of storm water would be about 50 per cent more than the amount required for treatment of the dry weather flow alone.

422

## BALANCING TANKS AND POUNDS IN THE SURFACE WATER DRAINAGE SYSTEM OF HEMEL HEMPSTEAD.

T.H. Carden.
Inst Munic Eng J, Vol 93, pp 24-25, 1966.
(through Water Pollut Abstr, Vol 40, No 4, pp 165-166, April 1967).

Descriptors: *Surface drainage, *Drainage systems, *Discharge (water), *Automatic control.
Identifiers: *Storage tanks, *Urban drainage, Capacity.

The author describes further improvements to the new surface-water drainage system already in operation in Hemel Hempstead, Herts. A further pound is under construction to deal with run-off from one of the new development areas and discharge to the river Gade will be regulated by automatic switches; a further balancing tank is also under construction in the Ver catchment area, with a capacity of 1 1/2 mil. ft$^3$. The balancing tanks and their functions are described and it is suggested that considerable saving can be achieved by the use of a storage unit in suitable drainage schemes where existing facilities for disposal are inadequate.

423

## STORM-WATER TANKS IN THE COMBINED SEWERAGE SYSTEM OF BERLIN.

A. Cohrs.
Gas Wasserfach, Vol 103, pp 947-952, 1962.

Descriptors: *Storm runoff, *Design, *Construction, Sewage treatment, Cities.
Identifiers: *Storage tanks, Berlin, Germany.

An illustrated description of the design and construction of storm-water tanks in the sewerage system of Berlin is presented.

424
WEST BRIDGFORD'S 1897 SEWAGE WORKS WILL BE MODERNIZED BY 1964.

Munic Eng, Vol 139, p 1277, 1962.
(through Water Pollut Abstr, Vol 37, No 5, p 163, May 1964).

Descriptors: Sewage treatment, *Storm runoff, Pumping.
Identifiers: *Storage tanks.

Mining subsidence prevented the building of a new sewage plant for West Bridgford,and it was decided to convey all sewage to the Nottingham treatment plant. The district, which has a population of 3,500 has been divided into five drainage areas. All sewage will be collected at a new main pumping station, and storm-water tanks and an outfall to a watercourse will be provided for high flows.

425
BIOLOGICAL FILTRATION USING A PLASTIC FILTER MEDIUM.
Water Pollution Research Laboratory, Stevenage.
G.E. Eden, G.A. Truesdale, and H.T. Mann.
Inst Sewage Purif J Proc, Pt 6, pp 562-574, 1966. 3 tab, 7 fig, 7 ref.

Descriptors: *Sewage treatment, Biochemical oxygen demand, Sewage effluents.
Identifiers: *Suspended solids.

Experiments in the use of the Dow "Surfpac" fabricated plastic medium for use in percolating filters are described. The material was tested in comparison with 2 1/2 in. rounded gravel, and with granite and at various rates of sewage application and BOD loads. It seems clear that effluents of high quality cannot be expected from media of this type; their advantage seems to lie, rather in their ability to accommodate large volumes of film and to permit the rapid passage of suspended matter, as in the treatment of unsettled liquids.

426
SEWAGE TREATMENT. VII. SEPARATION AND TREATMENT OF STORM WATER.

L.B. Escritt.
Contract Rec, Vol 59, No 32, p 11, 1948.

Descriptors: Sewage treatment, *Storm runoff, *Flow control.
Identifiers: *Storage tanks.

Methods of dealing with storm water flow at sewage works with and without storm tanks are described. The design of orifices for control of the flow to the sewage works is discussed.

427
SEWAGE TREATMENT PROCESSES. IV. STORM TANKS.

L.B. Escritt.
Water Wastes Treat J, Vol 6, pp 407-8, Sept-Oct, 1957.

Descriptors: *Storm runoff, Pumping, *Flow control, Sewage treatment.
Identifiers: *Storage tanks, *Capacity.

This article deals with the reasons for using storm tanks to serve as storage or holding tanks to prevent the discharge of excessive storm infiltration to the treatment works. Points discussed are purpose of storm tanks, theoretical capacity of tanks, storm water separation, storm tank details, and balancing flows from pumping stations.

428
SEWAGE TREATMENT AT SLOUGH.

John Finch.
Effluent Water Treat J, Vol 4, pp 275-77, June 1964.

Descriptors: *Storm runoff, Sewage treatment.
Identifiers: * Storage tanks.

Sewage treatment works serving the Borough of Slough, next to the lower terraces of the Thames River, are discussed with special emphasis on the design features necessitated by flat topography, high ground water table, and location of the plant site only a few feet above river level. The entire flow is pumped before entry into the plant. The flow is subject to comminution and grit removal. Excessive storm flows are bypassed to storage tanks to be returned to sewage flows when conditions are favorable. Flow is then divided. The high-level plant consists of primary settlement in a circular flow tank, high intensity aeration, effluent treatment by trickling filters, final settling, and disposal to the Thames River. The low-level plant consists of horizontal-flow, rectangular tanks without mechanical sludge removal equipment. Low-level plant flow is divided between standard rate filters and aeration units. When plant modification is complete, the entire flow will be aerated, filtered, and settled. Humus sludge and surplus activated sludge are pumped to primary tanks to be settled out with primary sludge. Sludge is thickened and digested.

429

### COMPLETION OF FURTHER STAGE IN GRANGEMOUTH DRAINAGE SCHEME.

J.M. Fraser.
Consult Eng, Vol 23, pp 550-553, 1963.
(through Water Pollut Abstr, Vol 37, No 2, p 57, Feb, 1964).

Descriptors: *Sewage treatment, Equipment, Discharge (water).
Identifiers: *Combined sewers.

The new combined sewerage system to serve the Bowhouse area of Grangemouth, Stirlingshire, is described. At the pumping station, flows up to 6 times dry-weather flow are comminuted before discharge to the Forth estuary 270 yards offshore; this volume of sewage will later be treated at a new sewage works which is to be constructed. Flows in excess of 6 times dry-weather flow are screened and discharged to the river Avon.

430

### THE EFFICIENCY OF CONVENTIONAL SEWAGE PURIFICATION WORKS, STABILIZATION PONDS, AND MATURATION PONDS WITH RESPECT TO THE SURVIVAL OF PATHOGENIC BACTERIA AND INDICATOR ORGANISMS.

O.J. Coetzee, and N. Fourie.
Proceedings, Resolutions, and Papers of the Conference on the Problems Associated with the Purification, Discharge and Re-Use of Municipal and Industrial Effluents, Natl. Inst. Water Res., Pretoria, 1964, pp 93-108.

Descriptors: Sewage treatment, *Sewage effluents, *Storm runoff, Sewage lagoons, *Bioindicators, *Pathogenic bacteria.
Identifiers: *Bacteriological sampling.

Tabulated and graphical results are presented from studies on the removal of Esch. coli, Salmonella typhi, Pseudomonas aeruginosa, and clostridium perfringens at various stages of the conventional sewage treatment process (using double filtration) and in lagoons. Neither system gave a safe effluent, but the lagoons are considered safer since there were no increases in any species of bacteria at any time. Lagoons have the additional advantage that all crude sewage, even during storms, receives treatment and none is by-passed. Results indicate that Esch. coli is not an infallible indicator for the presence of pathogenic organisms; a new indicator organism is needed and it is considered that an indicator fungus would have certain advantages which are listed.

431

DISPOSAL OF STORM WATER BY GROUND WATER RECHARGE.

G. Gongguy.
Calif Dep Water Resources-Biennial Conf on Ground Water Recharge & Ground Water Basin Management-Proc, 1963. 10 p.
(through Eng Index, p 1743, 1964).

Descriptors: *Storm runoff, *Groundwater recharge, *Highways.
Identifiers: *Capacity.

Utilization of excavated pit type of recharge basin for collection and disposal of storm water from roadways in various areas of San Joaquin Valley, Calif. is discussed. Basins vary in size from 1-6 acres, depending on storage requirement, and are located close to roadway. Usually, basins are used as material sites for roadway embankment material.

432

AUTOMATED PUMPING STATIONS FOR OUR NATION'S CAPITAL.

E.E. Halmos.
Water Sewage Works, Vol 114, No 9, pp 319-321, Sept 1967.

Descriptors: *Automatic control, Sewage treatment, *Storm runoff, Pumping, Sewers.
Identifiers: *Storm sewers, *Interceptor sewers, *Urban drainage, Sewer separation, *Washington, DC.

Two new installations are described. The Potomac Station is an automated plant which handles sewage and stormwater from the sewage interceptor line serving Dulles Airport and other Virginia and Maryland communities. The "O" St. Station handles sewage and stormwater from a redevelopment area where 100 acres of slum are being replaced. Both units will eventually bypass the main station which has 4 sanitary pumps operating at near their capacity of 280 mgd; the six stormwater pumps can handle up to 480 mgd. The city has totally separated storm and sanitary sewers. The pumps and the operation procedures of the station are described.

433
WESTON-SUPER-MARE'S NEW DRAINAGE SCHEME.

J.R.F. Hewish.
Inst Munic Eng J, Vol 93, pp 30-32, 1966.
(through Water Pollut Abstr, Vol 40, No 4, p 166, April 1967).

Descriptors: *Sewage treatment, Pumping, *Storm runoff.

The new drainage scheme of Weston-super-Mare, Somerset, is described in more detail, with particular reference to the dry-weather-flow and storm-water pumps, the system of power supply which involves electric power from the mains, two diesel alternators to reduce the maximal demand from the mains, and an emergency generator,and the system of alarm to warn of the danger of flooding. In continued dry weather the flow to the station is 400,000 $ft^3$ per day or 57 gal per head per day. (Similar article published in Surveyor, Lond, Vol 121, pp 1268-1269, 1962).

434
PROVIDING PRIMARY TREATMENT FOR STORM SEWAGE OVERFLOWS.

W.C. Hirn.
Wastes Eng, Vol 33, 1962.

Descriptors: *Storm runoff, *Overflow, *Sewage treatment, Sewage sludge, Sedimentation.
Identifiers: *Interceptor sewers, *Urban drainage, *Combined sewers.

The Milk River Drain project which serves Grosse Pointe Woods and Harper Woods to the northeast of Detroit, Mich., is described. Sewage is discharged to the Grosse Pointe interceptor which discharges to Detroit municipal sewers; combined flows in excess of 8000 gal per min are diverted to a sedimentation-skimming tank to remove sludge before discharge to Lake St. Clair. Settled sludge is periodically flushed from the sedimentation tank and discharged to the Grosse Pointe interceptor for treatment at the Detroit sewage-treatment plant.

435
DESIGN AND OPERATING EXPERIENCES AT THE NEW WORSLEY U D C SEWAGE WORKS.

J.M.A. Hope.
Inst Sewage Purif J Proc, pp 455-458, 1965.
(through Water Pollut Abstr, Vol 39, No 12, p 411 Dec 1966).

Descriptors: *Sewage treatment, *Storm runoff, Overflow.

The new sewage works serving Worsley, Walkden, and Little Hulton, Lancs., are designed to treat 1 m.g.d. of mainly domestic sewage by the activated-sludge process with Simplex aeration cones; there are no storm overflows on the sewers near the works and full treatment is provided for flows up to 4 times dry-weather flow and the remainder receives primary treatment. Experiences in the initial operation of the plant are outlined.

436
EFFECT OF STORAGE AND SKIMMING ON COMBINED SEWAGE OVERFLOWS.
Hubbell, Roth & Clark, Inc., Consulting Engineers, Bloomfield Hills, Mich.
George E. Hubbell.
Presented at the 39th Ann Conf of the Water Pollut Contr Fed, Kansas City, Mo, Sept 25-30, 1966, figs. tables.

Descriptors: Drainage systems, *Weirs, Outlets, Flowmeters, Rain gages, Sampling, *Overflow.
Identifiers: *Combined sewers.

The first year's operation of the Twelve Town Drainage District's relief drainage system is reported. A high weir skimming structure at the outlet is described, and flow metering, a rain gage network, and laboratory facilities at the Outlet Structure (including automatic samplers) are noted. Sewage and overflow characteristics are compared, and primary settling is viewed as not likely to produce significant changes.

437
[DESIGNING OF SEWERAGE SYSTEMS]. De dimensioneering van rioolwaterzuiveringsinrichtingen.

A.C. Koot.
Water, Vol 51, No 8, pp 165-69, Apr 20, 1967. 4 fig., 2 tab.
(through Public Health Eng Abstr, Vol 47, No 11, p 388, Nov 1967).

Descriptors: *Design, *Sewers, *Storm runoff, *Overflow.
Identifiers: *Capacity.

The author summarizes the designing of grit chambers, primary and secondary sedimentation tanks, low-and high-rate trickling filters, low- and high-rate activated sludge plants, and digestion tanks. Sufficient storage capacity in or in addition to the sewerage system for storm overflows is also discussed.

438
SOME PROBLEMS IN THE HYDRAULIC DESIGN OF SMALLER TREATMENT WORKS.

J. Lang.
Inst Sewage Purif J Proc, Pt 5, pp 482-490, 1964.
(through Water Pollut Abstr, Vol 39, No 2, p 51, Feb 1968).

Descriptors: *Hydraulic design, Sewage treatment, *Storm runoff.

The author discusses some of the difficulties encountered in designing small sewage works which have small dry-weather flows but may receive large volumes of storm sewage.

439
NO STORM-WATER BYPASS.
Sewerage Commission, Milwaukee, Wis.
R.D. Leary.
Amer City, pp 93-95, Aug 1966.

Descriptors: *Sewage treatment, Equipment, *Storm runoff.

A sewage purification plant for Milwaukee is described in detail. Primary treatment is provided for an average flow of 60 mgd and can be expanded to a dwf of 120 mgd by the year 2000. Secondary treatment is also planned for the future. The plant is designed so that each part can handle the entire flow hydraulically. Any unit can be taken out of service for maintenance and the balance of units will handle the entire 320 mgd stormflow. Therefore no plant bypass is needed and no untreated sewage flows to the lake.

440
PUBLIC HEALTH ENGINEERING IN A NEW TOWN-PROGRESS AND PROBLEMS.

H.J. Lumley, H.B. Parker, and T. Steel.

Inst Public Health Eng J, Vol 66, pp 18-33, 1967.
(through Water Pollut Abstr, Vol 41, No 3, p 118, March 1968).

Descriptors: *Surface runoff, *Discharge (water), *Intakes, Sewage treatment.
Identifiers: *Combined sewers, Urban drainage.

This discussion on public health services in Crawley New Town, Sussex, includes a description of sewerage and sewage disposal facilities. The new sewerage system was designed to carry surface water directly to local streams and the river Mole; the only surface water to go into the foul sewer was to be that from the existing combined sewers. In practice this system has failed and the treatment works, which was designed to take a storm flow of 12 m.g.d., has, under extreme conditions, had to deal with 18 m.g.d. Penstocks had to be fitted to the sewer inlets to prevent flooding at the works, with the resultant "backing up" of sewers in many parts of the town when these are closed. Various causes of the excessive storm flow have been suggested. The new sewage works provide treatment by the activated-sludge process, with diffused-air aeration. Sludge is digested and used as fertilizer on farmland. With an effluent standard of 15 p.p.m. suspended solids and 15 p.p.m. BOD to maintain and improve upon, it may soon become necessary to duplicate the works to deal with the sewage from a rapidly expanding population. The master plan for Crawley failed to make any provision for refuse disposal; as a result two unsatisfactory attempts have been made to establish controlled dumps. The first site had to be closed when liquor draining from it polluted a stream which developed heavy growths of sewage fungus. At the second site an attempt was made to terrace a hillside, but as a result of geological faulting local streams were again polluted. This situation has been alleviated by digging drainage trenches at the base of the hill to collect the effluent which is then pumped back up the hillside for treatment on land. This has not entirely removed the pollution or the accompanying smell of hydrogen sulphide, and as a further measure potassium permanganate, which precipitates the hydrogen sulphide, is leached into the streams. The cost of mechanical methods of disposal are at present prohibitive and a long-term plan for refuse disposal is not yet possible.

441
DWF OF 282,000 GPD FOR BRENTWOOD SEWAGE WORKS.

T.V. Martin.
Munic Eng, London, Vol 142, pp 1375-1376, 1965.
(through Water Pollut Abstr, Vol 39, No 12, p 409, Dec 1966).

Descriptors: *Automatic control, Sewage treatment, Equipment, Sewage sludge, Sewage effluents, *Storm runoff.
Identifiers: *Storage tanks.

The new sewage works of Brentwood, Essex, replacing the Lapwater Hall works which served a population of 1500, is designed to serve a population of 8000, with a design dry-weather flow of 0.282 m.g.d. Flows in excess of 3 times this value are automatically diverted to storm tanks from which flows in excess of 6 times dry-weather flow are discharged to irrigation plots and smaller flows pass with the settled sewage to the percolating filters. The rate of recirculation of effluent on to the filters is also controlled automatically in relation to the rate of the incoming flow. Final effluent is discharged to grass plots but flows in excess of 3 times dry-weather flow are pumped direct to the river. Sludge is digested and dried on beds; liquor from the digestion tanks and drainage from the drying beds are re-treated with the influent sewage.

442
TURKEY CREEK SEWAGE PUMPING STATION.

W.E. Nusbaum.
Sewage Works, Vol 112, No 2, pp 58-62, Feb 1965.
(through Eng Index, p 2229, 1965).

Descriptors: *Water pollution control, *Storm runoff, *Automatic control.

Plant in conjunction with new diversion structure is part of plan for pollution control of Missouri River and will be located near mouth of Turkey Creek trunk sewer; sanitary sewage and industrial wastes will be intercepted and pumped through 48-in. force main to new sewage treatment plant located near confluence of Kansas and Missouri Rivers; storm flows will be bypassed directly to Kansas River; plant is equipped with five sewage pumping units of vertical, dry-pit type driven through direct connected intermediate shafting by electric drives mounted separately on main operating floor; pump operation, electrical supply and automatic features are described.

443
SOME APPLICATIONS OF RESEARCH IN THE DESIGN OF SEWERAGE AND SEWAGE-TREATMENT WORKS.

H.R. Oakley.
Inst Sewage Purif J, Pt 1, pp 83-101, 1963.
(through Water Pollut Abstr, Vol 37, No 5, pp 161-162, May 1964).

Descriptors: *Storm runoff, *Runoff forecasting, Hydraulic design, Sewage treatment, Design, *Sewers, Equipment.

The author discusses some examples of the application of results of research to improve the design of sewerage and sewage-treatment facilities, including calculation of storm-water run-off, hydraulic design of sewers, design of sedimentation tanks and percolating filters, improved aeration in the activated-sludge processes, and methods for polishing effluents and for treatment of sludge. He points out that direct application of fundamental research to design is seldom possible, and an intermediate stage of development is usually necessary.

444
EMERGENCY ALUM TREATMENT OF OPEN RESERVOIRS.

W. R. Ree.
Amer Water Works Ass J, Vol 55, pp 275-281, 1963.
(through Water Pollut Abstr, Vol 37, No 5, p 154, May 1964).

Descriptors: *Storm runoff, *Treatment, Water pollution control, *Turbidity.
Identifiers: *Storage tanks.

The author describes experiences of the Department of Water and Power, Los Angeles, Calif., in the direct application of powdered alum to open reservoirs for reduction of high turbidities caused by storm run-off. This treatment has been found useful in emergencies, satisfactory results being obtained with alum doses of up to 85 p.p.m. It has also been used successfully for treatment of storm water before it enters the reservoirs. Experiments also showed that the storm water could be treated with liquid alum, and large storage tanks are being constructed at two sites for this purpose, to eliminate the need for mechanically driven feeders.

445
CONTROL OF POLLUTION FROM COMBINED SEWER SYSTEMS.
Div Water Supply and Pollut Contr, HEW, Washington, D. C.
Paul W. Reed.
Paper presented at the 1965 Public Works Congress and Equipment Show, sponsored by Amer Public Works Ass, Los Angeles, Calif, Aug 31, 1965.
10 p, 8 ref.

Descriptors: *Storm runoff, *Water pollution, *Overflow, Sewage treatment.
Identifiers: *Combined sewers, *Sewer separation, Storage tanks.

Data from several cities concerning amount of pollution due to storm water overflow from combined sewers is given. Disadvantages of separating sanitary and storm sewers as a solution for the problem are discussed. Combined treatment and holding facilities are suggested as an alternative and various types are described. (Synopsis of this paper published in Public Works, pp 112-113, Aug, 1966).

446
SOUTHEND-ON-SEA SEWAGE WORKS AND PUMPING STATIONS.

J.H.D. Sayle.
Inst Sewage Purif J, Pt 3, pp 242-244, 1963.
(through Water Pollut Abstr, Vol 37, No 8, pp 268-9, Aug 1964).

Descriptors: *Sewage treatment, *Storm runoff, Pumping.

The pumping stations and sewage-treatment facilities for Southend-on-Sea, Essex, are described. Sewage is treated at Prittlewell by screening, removal of grit,and sedimentation before discharge to the Thames estuary; storm water is screened before discharge, and all screenings are disintegrated. Sludge is now digested before being pumped to the sludge farm at Barling. Provision has been made for returning water draining from the sludge farm to the main treatment plant, but in dry weather this effluent is used by farmers for crop irrigation.

447
TREATMENT OF MUNICIPAL WASTE WATER.

O.J. Schmidt.
S.W. Water Works J, Vol 48, No 5, pp 18-28, 1966.
(through Water Pollut Abstr, Vol 41, No 1, p 28, Jan 1968.

Descriptors: *Runoff, *Water pollution, Sewage lagoons, Biochemical oxygen demand, Sewage treatment, Design.

The author discusses sources of pollution, including examples of pollution by run-off, and describes the performance of lagoons used for tertiary treatment at Peoria, Ill., at South St. Paul, Minn., and at Indian Creek, Kans. BOD removals during the periods studied ranged from 20 to 70 per cent. It is pointed out that it is difficult to assess the efficiency of influent BOD changes from a carbonaceous to a nitrogenous nature. The high efficiency of tertiary treatment is illustrated by results from the plant at South Tahoe, Calif. Reduction of pollution by improvements in the design and operation of sewage works and by chemical treatment is considered briefly.

448
METHOD OF CLEANING SEWER SYSTEMS.

E. J. Storia, and R. L. Voda.
U.S. Patent 3,170,814, (to Terra Chemical Corp) Feb 23, 1965.

Descriptors: *Sewers, *Storm runoff.
Identifiers: Combined sewers, *Polymers.

It is claimed that storm-water and combined sewerage systems can be cleaned by adding a water-soluble, high-molecular-weight polyelectrolytic organic polymer, such as acrylic and methacrylic acid derivatives, to the catch basins in amounts of 0.1 - 1.0 gal. Rain water entering the system dissolves the polymer which acts as a coagulant for material in the sewer, and carries it through the system to discharge.

449
SAINT NICOLAS: TECHNICAL DESCRIPTION OF THE SEWAGE-TREATMENT WORKS.

M. Theinpont.
Techq Eau Assain, Vol 19, No 219, pp 29-40, and No 220, pp 29-40, 1965.
(through Water Pollut Abstr, Vol 40, No 4, pp 167-8, April 1967).

Descriptors: *Storm runoff, *Sewage treatment, Automatic control, Sewage sludge, Sewage effluents.

A detailed, illustrated description is given of the new biological-filtration plant at Saint-Nicolas, Belgium, which has been designed to treat a daily dry-weather flow of 10,800 $m^3$ of sewage and industrial wastes, with provision for reception of 3200 $m^3$ per hour during storm flows, half of which can receive complete treatment. The percolating filters may be operated with alternating double filtration and recirculation, and the final effluent is discharged from humus tanks to Paddeschootbeek. Sludge receives primary and secondary digestion, during which it is heated by heat-exchange units situated outside the tanks; after drying on beds, the digested sludge provides a useful fertilizer. The operation of the plant is controlled automatically from a central control room, and its flexibility is illustrated by appended flow diagrams.

450
SEWERAGE AND STORM-FLOW TREATMENT.

D. J. Weiner.
Water Pollut Contr Fed J, Vol 39, No 5, pp 741-746, 1967. 39 ref.

Descriptors: *Surveys, *Storm runoff, Sewage treatment, Tunnel construction, Instrumentation.

A brief review of the 1966 literature on sewerage and storm-flow treatment is presented. Topics included are tunnel construction, economics of pollution control measures, specific sources of run-off pollution, sewer maintenance programs, and the use of television in sewer inspection.

451
GROUND WATER RECHARGE - CONSERVATION IN NASSAU COUNTY.

Fred W. Welsch.
Amer Water Works Ass J, Vol 52, p 12, 1960.

Descriptors: *Storm runoff, *Groundwater, Outlets, *Drainage, *Stilling basins, Chemical analysis.
Identifiers: *Surface permeability.

Ground water replenishment with storm water serves several purposes: 1. replenish ground water supply, 2. provide drainage outlets without long conduits, and 3. reduce size of conduits for storm water drainage. Recharging done in several ways: 1. for small areas large dia. diffusion pipe installed in caisso. fashion, 2. single basin recharge reservoirs, and 3. two unit basins, first one to act as settling basin and second as seepage or percolation basin. Designed on a 5 in. rainfall in 2 days which has a frequency of about 5 years. Runoff coefficients increasing as area develops and previous area decreases. Seepage rates for area are approximately 24 gpd/$ft^2$ or 1 mgd/acre. Analyses of storm water basins indicate chlorides of 2.4 ppm, iron 0.1 - 0.8 ppm and D.S. of 132 - 218 ppm. Phenols have been found where runoff is from pavements of bituminous tar material.

# Section X

# URBAN HYDROLOGY

452
ASCE'S URBAN WATER STUDIES.

ASCE, Newsletter Sanit Eng Div, p 1, July 1968.

Descriptors: *Design, *Storm drainage, Data collections, Instrumentation, *Rainfall-runoff relationships, *Water quality, Model studies.
Identifiers: *Urban drainage, *Urban hydrology, Storage tanks.

ASCE has initiated a study program on urban hydrology consisting of two projects. "An Analysis of National Basic Information Needs in Urban Hydrology" is a study to determine the kinds of data needed to improve the design of an urban area's storm drainage facilities; needs for data-collecting instrumentation; and appraisal of the types of networks necessary to collect adequate data. "A Systematic Study and Development of Long-Range Programs of Urban Water Resources Research" aims to furnish guidelines for initiating and expanding a long-range study on urban water problems; conduct a state-of-the-art study of simulation methods potentially usable for analyzing urban rainfall-runoff-quality processes; and study the requirements for assessment of drainage damage and the use of storage schemes. The non-hydrologic aspects of urban water-resources research needs will also be investigated.

453
ASCE RESEARCH PROGRAM IN URBAN WATER RESOURCES.

Civ Eng, Vol 38, No 5, pp 70-71, May 1968.

Descriptors: Data collections, *Design, *Storm drainage, Instrumentation, *Rainfall-runoff relationships, *Water Quality, Model studies, Drainage systems.
Identifiers: *Urban drainage, *Urban hydrology.

The ASCE Urban Hydrology Research Council has initiated a program to study and report on research and data needs for urban-water problems. The program currently consists of two major projects: Research and Analysis of National Basic Information Needs in Urban Hydrology and Systematic Study and Development of Long-Range Programs of Urban Water Resources Research. Under the first project an intensive study is being made of the types of data needed for improved design of storm-drainage facilities, including both quantity and quality of drainage-flow needs for data-collecting instrumentation; and for approval of types of networks necessary to collect adequate data. The ultimate objective is to facilitate transfer of data findings between metropolitan regions. The second project will attempt to provide guidelines for initiating and expanding a program of long-range studies on urban water problems. This includes: prefeasibility studies to determine the possible effectiveness, cost and time requirements for a comprehensive systems-engineering analysis of all aspects of urban water and for a general economic analysis of costs and pricing parameters of all aspects of urban water; a state-of-the-art study of mathematical models and related techniques for analyzing urban rainfall-runoff-quality processes; a study of requirements for the assessment of drainage damage and exploration of alternatives to direct storm-water runoff; and a study of political, economic, legal, and social problems related to urban water management.

454
SANITARY SERVICES. GREAT ACHIEVEMENTS FOR A PLAN OF WORKS.

Rev Obr Sanit Nac, B Aires, Vol 42, pp 164-185, 1960.
(through Water Pollut Abstr, Vol 37, No 1, p 3, Jan 1964).

Descriptors: *Planning, *Sewers.
Identifiers: Storm sewers, *Argentina.

After a review of legislation relating to the provision of water supplies and storm and sanitary sewerage systems in Argentina, brief descriptions are given of the facilities in operation, under construction, and planned, for more than a hundred different urban centers, each considered individually. A map is included showing the position of water supply and sewerage systems throughout the country.

455
ATTENUATION OF FLOOD WAVES IN PART-FULL PIPES.

P. Ackers, and A. J. M. Harrison.
Inst Civ Eng Proc, Vol 28, Pap No 6777, pp 361-381, 1964.
(through Water Pollut Abstr, Vol 38, No 2, p 57, Feb 1965).

Descriptors: Pipes, *Hydrographs, *Floods, *Conduits.
Identifiers: *Storm sewers.

In the derivation of improved methods for designing storm-water drainage systems it is important to know the way in which the flood hydrograph (or flood wave) is modified as it passes along a conduit under conditions of free surface flow; and an extensive study was therefore carried out using an experimental pipeline installation in which the slope, height, and length of peak of the input hydrograph could be varied. For each set of conditions, depth-time data were automatically recorded and analyzed in terms of dimensionless parameters, showing that the rate of lowering of the wave peak with time and with distance is a function of the pipe diameter, the Froude number, the depth of base flow, and the volume of fluid in the wave. The volume of the wave, not its shape, is the principal factor affecting the attenuation. The velocity of the peak of the wave was found to be in good agreement with the Kleitz-Seddon law. The peak depth of the wave is a function of the peak discharge, which is related to the steepness of the wave, but in most practical cases differs little from the normal discharge. As dimensionless parameters were used, the results are applicable to storm sewers of all diameters and floods of all durations and magnitudes, provided the hydrograph is not steeper than those studied.

456
APPLICATION OF STORAGE ROUTING METHODS TO URBAN HYDROLOGY.

A. P. Aitken.
Inst Eng, Australia J, Vol 40, No 1-2, pp 5-11, Jan-Feb 1968.
(through Eng Index, p 235, Aug 1968).

Descriptors: *Storm runoff, Design, Design storm.
Identifiers: *Urban drainage.

Methods of runoff routing developed in Great Britain and in United States are examined and extended in application, so that results may be applied as correction to "rational method" of design. Rational method is specifically derived for localities like Victoria and Great Britain, where runoff from pervious area for design storm is of no significance, but it could be applied in other areas with suitable modifications.

457
THE USE OF UNIT-SOURCE WATERSHED DATA FOR RUN-OFF PREDICTION.

C. R. Amerman.
Water Resources Res, Vol 1, pp 499-507, 1965.
(through Water Pollut Abstr, Vol 40, No 5, p 212, May 1967).

Descriptors: *Runoff forecasting, *Demonstration watersheds, Subsurface runoff, Storms.

Run-off from 10 units forming a 76-acre complex watershed and from 2 units forming a 7.4-acre complex watershed in the North Appalachian experimental watershed near Coshocton, Ohio, was measured during storms during 1956. The partial run-off values were used to calculate a theoretical value for the run-off from each complex watershed, which was compared with the observed run-off. For the 76-acre watershed, the observed run-off was very much larger than the estimated run-off for small storms, but the two values approached as the storm size increased; in the case of the 7.4-acre watershed the estimated value was very much larger than the observed run-off for small storms and almost equal to it for large storms. In order to produce a better model for this type of calculation it was concluded that the question of sub-surface run-off, partial area flow, and the influence of run-off from the upper slopes on that from lower areas, should be considered.

458

AN EVALUATION OF THE INFLOW-RUNOFF RELATIONSHIPS IN HYDROLOGIC STUDIES.

J. Amorocho, and G. T. Orlob.
Univ Calif, Water Resources Center Contri, No 41, 1961. 70 pp.
(through Water Pollut Abstr, Vol 37, No 3, p 83, March 1964).

Descriptors: *Rainfall-runoff relationships, *Model studies.

Studies have been carried out by the University of California to establish some of the criteria required for the interpretation of statistical analyses of the relation between rainfall and run-off. For this purpose, a model of an hydrological unit was developed, based on a qualitative analysis of its fundamental functional elements, and its structure was compared with that of a typical regression equation. The conditions for minimum error in the estimates of flow from catchments were examined and various watersheds in different parts of the world were investigated to test the applicability of the equations of state developed. The advantages of using an equation of state for hydrologic studies in preference to wholly empirical relations derived from more or less arbitrary multiple correlation analyses are indicated.

459
DRAINAGE AND BEST USE OF URBAN LAND.

Louis H. Antoine, Jr.
Public Works, Vol 95, p 2, Feb 1964.

Descriptors: *Land use.
Identifiers: *Urban drainage, *Surface permeability, St. Louis, Mo.

This article discusses a study of drainage channels for the St. Louis area and gives data on the percent of imperviousness for different urban land uses.

460
DETERMINATION OF RUNOFF FOR URBAN STORM WATER DRAINAGE SYSTEM DESIGN.

K. W. Bauer.
Southeastern Wis Reg Plng Comm Tech Rec, Vol 2, No 4, April 1965. 19 pp.
(through Highway Res Board).

Descriptors: *Storm runoff, *Design, *Planning, *Drainage systems, *Rainfall intensity, Runoff.
Identifiers: *Urban drainage, *Storm sewers.

Storm water runoff determinations are made to determine design criteria for the planning and design of urban drainage systems. The storm water runoff determination criteria is the rational method whose variables are: the coefficient of runoff, rainfall intensity for the area, time of concentration, and soil information. The application of these criteria should promote common storm sewer design methods and the adoption of common design methods for storm water drainage system design.

461
TIME ANALYSIS OF RAINFALL ON URBAN CATCHMENT.

V. J. Bidwell.
J Hydrol, New Zeal, Vol 6, No 2, pp 74-9, 1967.
(through Eng Index, p 215, July 1968).

Descriptors: *Rainfall intensity, *Computer programs, Rain gages.
Identifiers: *Urban drainage, *New Zealand.

Analysis of short-time-increment rainfall at University of Auckland in New Zealand is presented. Autocorrelation techniques proposed by R. A.

Grace and P. S. Eagleson were used. Practical methods of data recording and processing, suitable for digital computer analysis, are outlined. Autocorrelation results are given for 1 yr of 10-min rainfall values for Albert Park gage at Auckland.

462
CALCUTTA. 2. A SANITARY ENGINEERING APPROACH TO A MULTIPLICITY OF PROBLEMS.

P. C. Bose, and R. G. Ludwig.
Water Sewage Works, Vol 112, pp 164-167, 1965.
(through Water Pollut Abstr, Vol 39, No 9, pp 303-4, Sept. 1966).

Descriptors: *Flood control, Drainage systems, *Design, Storms, Sewage treatment, *Storm runoff.
Identifiers: *Capacity, *Combined sewers, *Storm sewers, Calcutta, India.

To improve the sewerage system at Calcutta and alleviate flooding during the monsoon period it is proposed to increase the capacity of the existing combined sewers and drainage channels, provide connections to the trunk sewers, and construct separate sewers for storm water and sewage in the unsewered districts, using 2-month storm frequency data as a design basis for the urban sections. Treatment works are planned for the districts of Tollygunge, Cossipore-Chitpore, Howrah, and Chandernagore.

463
STEPS TOWARD A BETTER UNDERSTANDING OF URBAN RUNOFF PROCESSES.

E. F. Brater.
Water Resources Res, Vol 4, No 2, p 335, Apr 1968.

Descriptors: *Rainfall-runoff relationships, Drainage systems, Surface runoff, *Storm runoff, Groundwater.

Rainfall and runoff from drainage basins in various stages of urbanization were analyzed to determine the initial retention, the hydrologically significant impermeable area, and the infiltration capacities of the permeable portions of the basins. The drainage basins, varying in size from 9.5 to 185 square miles, are located in the Detroit metropolitan area. Techniques were developed that largely eliminated personal judgment in separating surface runoff from ground water discharge. Infiltration capacities in this region are from 3 to 5 times higher in late summer than in early spring. The average initial retention for the basins studied is approximately 0.2 inch. The hydrologically significant impermeable area appears to be closely related to the population density, but the effect of other factors is being studied. An investigation of the cause of seasonal and short period variations of infiltration capacity may provide a better understanding of the infiltration process.

464
EFFECTS OF LAND USE ON WATER RESOURCES.

W. E. Bullard.
Water Pollut Contr Fed J, Vol 38, pp 645-59, Apr 1966. 23 ref.
(through Public Health Eng Abstr, Vol 46, No 10, p 359, Oct 1966).

Descriptors: *Land use, *Water quality, Sedimentation, Nutrients, *Water pollution, Runoff.
Identifiers: *Urban drainage.

Land use, among other factors, determines the quality of water produced. Erosion causes turbidity and sedimentation, lowers water quality, and damages aquatic life habitats. Fertilizers, pesticides, and other toxins and nutrients contribute to pollution. Agriculture, timber, mining, urban runoff, and recreation also are pollution contributors.

465
PERIMETER DRAINAGE TO PROTECT URBAN LANDS.

R. T. Chuck.
ASCE Proc, J Urban Planning Develop Div, Vol 93, No UP1, Paper 5055, pp 1-12, Jan 1967.
(through Eng Index, p 596, 1967).

Descriptors: *Drainage systems, *Planning.
Identifiers: *Urban drainage, Hawaii.

Perimeter drainage is challenging approach for providing drainage protection to urban lands. Essential in its concept is consideration of alternative uses of existing natural water courses. By using man-made waterways to supplement, alter, or entirely eliminate existing natural drainage pattern, perimeter drainage affords means of providing adequate protection to urban lands, while preserving and enhancing their economic and aesthetic values. Successful experience in Hawaii suggests that perimeter drainage has considerable merit in urban planning and development and should be given more serious attention in well-planned urban lands.

466
UNIT HYDROGRAPH CHARACTERISTICS FOR SEWERED AREAS.

Peter S. Eagleson.
ASCE Proc, J Hydraul Div, Vol 88, No HY2, Part 1, March 1962.

Descriptors: *Hydrographs, *Overflow, Sewers, Storms, Drainage.
Identifiers: *Storm sewers.

Hydrographs of measured storm sewer outflow from urban areas up to 7.5 sq. miles in size are analyzed. The characteristics of the hydrographs are correlated with the properties of sewers and drainage basins in order to permit construction of synthetic unit hydrographs for other unmeasured sewered areas. Applicability of the derived relationships is tested against a measured outflow hydrograph for a complex storm.

467
COMPUTATION OF OPTIMUM REALIZABLE UNIT HYDROGRAPHS.

Peter S. Eagleson, Ricardo Mejia-R, and Frederick March.
Water Resources Res, Vol 2, No 4, pp 755-764, 1966. 6 fig, 22 ref.

Descriptors: *Rainfall-runoff relationships, *Computer programs.
Identifiers: Calculations, *Urban hydrology.

The Wiener-Hopf theory of optimum linear systems is applied to the determination of the stable pulse response of a monotone hydrologic system from coincident records of input and output in the form of discrete time series. In application to the rainfall-runoff system, linear programming methods are used in the solution of the Wiener-Hopf equations to obtain physically realizable unit hydrographs. An actual urban rainfall-runoff event is graphed and used for illustration in developing the equation.

468
RAINFALL AT NEW ORLEANS AND ITS REMOVAL.

G. G. Earl.
Civ Eng, Vol 2, No 5, pp 289-94, May 1932.

Descriptors: *Drainage, *Pumping, *Discharge (water), Storms, *Rainfall intensity, Rain gages.
Identifiers: *Capacity, New Orleans, La.

Drainage and sanitation problems; pumping capacity required to discharge accumulation of water in reasonable time; records of storm; drainage pumping stations; effects of irregular rainfall; new type rainfall recorder; extending rainfall data; sanitary systems.

469
ECONOMIC SURFACE-WATER SEWERAGE: A SUGGESTED STANDARD OF PRACTICE.

L. B. Escritt, and A. J. M. Young.
Inst Public Health Eng J, Vol 62, 1963.

Descriptors: *Design, *Sewers, *Storm runoff, Storms, Surface runoff.
Identifiers: *Surface permeability, *Urban drainage.

In an examination of data, provided by the Road Research Laboratory, for use in the design of sewers, the authors question the conclusion that the amount by which calculated rates of runoff during storms exceed recorded rates is due to storage. They suggest that it is due to a change in impermeability of the catchment and describe an experiment, using a sheet of plate glass as a catchment, to support their views. The Lloyd-Davies method of calculation should be used, with the assumption that roofed and paved surfaces in developed areas have an impermeability of 80 percent and not 100 percent as the Road Research Laboratory suggests.

470
SCALE MODEL OF URBAN RUNOFF FROM STORM RAINFALL.

R. A. Grace, and P. S. Eagleson.
ASCE Proc, J Hydraul Div, Vol 93, No HY3, pp 161-176, May 1967.

Descriptors: Storms, *Model studies, Storm runoff.
Identifiers: *Urban drainage.

The response of a small urban watershed to four storms is generated in the laboratory by a scale model consisting of a programmed rainfall generator, vertically-distorted scaled topography, and a weighing device for recording the cumulative runoff. Comparison of these results with prototype measurements through use of derived scaling laws shows reasonable agreement.

471
EFFECT OF URBAN GROWTH ON STREAMFLOW REGIMEN OF PERMANENTE CREEK, SANTA CLARA COUNTY, CALIF.

E. E. Harris, and S. E. Rantz.
U S Geol Survey-Water Supply Pap 1591-B, 1964. 18 p.
(through Eng Index, p 1064, 1965).

Descriptors: *Storm runoff, *Land use.
Identifiers: *Urban drainage, Surface permeability.

Evidence that volume of storm runoff produced by rainfall on valley floor has increased substantially as result of urbanization is presented. Increase in outflow is attributed to fact that urban development during period 1945 to 1958 increased extent of impervious surface in project area from about 4 percent to 19 percent.

472
A METHOD OF COMPUTING URBAN RUNOFF.

W. I. Hicks.
ASCE Proc, Vol 109, 1217, 1944.

Descriptors: Hydraulics, *Rainfall-runoff relationships, *Hydrographs, *Runoff forecasting.
Identifiers: *Urban drainage.

The author presents results of hydraulic investigations and rainfall -

runoff gagings and develops hydrographs for different sized areas, with varying degrees of development and time of concentration.

473
URBAN HYDROLOGY - REDIRECTION.
Fed Housing Admin, Dep Housing and Urban Devel, Washington, D. C.
D. Earle Jones.
Civil Eng - ASCE, Vol 37, No 8, pp 58-62, Aug 1967.

Descriptors: *Drainage systems, Storm runoff, *Land use.
Identifiers: *Urban hydrology, *Urban drainage.

Inaccuracies of present hydrology methods are outlined. An improvement is suggested wherein the fact that cities have two separate and distinct storm water drainage systems, a "minor" and a "major" system would be recognized. The minor system consists of carefully designed closed and open conduits and their appurtenances. The major system is the route followed by flood or runoff waters when the minor system is inoperable or inadequate. Cities today are overdesigning the minor systems. A reasonable design would provide that ordinary vehicular access to properties be impaired no more often than once in 2-10 yrs. Wiser use of natural land conditions when developing the land can obviate extensive storm sewer construction. Examples are given of some methods for this wiser use e.g. "blue-green" land development employing ponds with open space for storm-flow detention.

474
STORM RUN-OFF FROM URBAN AREAS.

M. V. King.
Inst Civ Eng Proc, Vol 37, pp 43-56, Pap No 6996, 1967.
(through Water Pollut Abstr, Vol 40, No 8, p 352, Aug 1967).

Descriptors: *Storm runoff, Rainfall-runoff relationships, *Sewers, Hydrographs, Drainage systems, Design.
Identifiers: Urban drainage, *Urban hydrology, Surface permeability.

The author describes the development of a mathematical relation between rainfall and run-off in urban areas, taking into account various calculable characteristics of a drainage area and the retention action of a sewerage system as used in the Road Research Laboratory hydrographic method. It is shown that the peak flow for any particular frequency of storm depends on the time of concentration, the effective impervious area, and the total volume of water in the sewerage system at the time of peak runoff; only the last of these is difficult to determine, and for very large areas it is considered adequate to use an approximation. Having determined the retention constant for a drainage system under particular conditions, it is also possible to draw the complete run-off hydrograph. This method may be used in designing large sewers, but is not considered suitable for small ones.

475
ECONOMIC STUDY OF URBAN AND HIGHWAY DRAINAGE SYSTEMS.

J. W. Knapp.
Johns Hopkins Univ-Dep Sanit Eng & Water Resources-Tech Report 2, June 1965. 175 pp. 66 ref.
(through Eng Index, p 2578, 1966).

Descriptors: *Drainage systems, Design, *Highways, *Runoff, *Flood control, *Model studies, *Intakes.
Identifiers: *Urban drainage.

Characteristics of flood losses are investigated. Information collected on cost of drainage facilities and damages in urban areas is analyzed. For highway drainage, interruption of traffic flow is interpreted as major flood damage. Mathematical models are developed for solution of specific drainage problems. Simulation is used to describe random effects of runoff and traffic in model for selecting pumping facilities to remove storm water at highway underpass. Two models for finding optimum spacing of inlets are developed and solved.

476
SEWERAGE AND SEWAGE DISPOSAL IN RETROSPECT AND PROSPECT.

M. Lovett.
Surv, Vol 104, 587, 1945.

Descriptors: Sewage treatment, *Storm runoff, *Rainfall intensity, *Storms, Design.
Identifiers: *Combined sewers, *Great Britain, *Surface permeability.

The development of sewerage systems in Great Britain, and disposal and treatment of storm waters are described. In a particular district the extent of impervious areas, intensity of rainfall, localization of storms, and the nature, size, and use of nearby streams determine whether a combined or a separate sewerage system is more suitable.

477
### DETERMINATION OF RUN-OFF COEFFICIENTS.

F. W. MacDonald, and A. Mehn.
Public Works, Vol 94, No 11, p 74, 1963.

Descriptors: Drainage systems, *Land use, *Runoff.
Identifiers: Surface permeability, *Urban drainage, *New Orleans, La.

Results of a study to determine times of concentration and obtain an accurate value for the coefficient of imperviousness of one of the large drainage districts of the city of New Orleans, La., carried out in cooperation with the Sewerage and Water Board, are summarized in Tables and discussed. Results indicate that the coefficient for built-up areas, which comprise over 4000 acres in the district is 0.548 whereas the coefficient for a typical suburban area is 0.455; the coefficient for the entire drainage district is 0.559. The Rational formula was employed to determine run-off coefficients using a 79-minute time of concentration, and the average value obtained was 0.653, this value being within the ranges recommended for combined residential and commercial areas.

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478
### DETERMINATION OF THE DISCHARGE OF RAIN WATER.

G. Mueller-Neuhaus.
Gesundh Ing, Vol 68, pp 143-8, 1947.

Descriptors: *Storm runoff, *Discharge (water), Sewers.

A graphical method for the determination of the discharge of rain water through sewers taking into account the influence of the gradient and cross-sectional area is described.

479
ALLOCATION OF STORM DRAINAGE COSTS.

Carl W. Porter.
Public Works, Vol 94, No 3, pp 164-166.

Descriptors: *Rainfall-runoff relationships, *Storm runoff, *Planning, *Legislation, *Flood control, *Land use, Drainage.
Identifiers: Urban drainage.

Article is portion of "Paper" presented at 1962 American Public Works Congress. It describes program used in the County of Fairfax, Va. Also states that they are working with U.S.G.S. on a pilot program studying 30 main streams in the County endeavoring to determine rainfall patterns and relate runoff from currently developed areas to storm water runoff. Also have an anti-siltation ordinance with SCS. Article discusses plans and ordinances used to protect the suburban homeowner from inadequate drainage and also protect the downstream property owner from flood damage due to increased runoff from newly developed upstream areas.

480
STORM WATER DRAINAGE IN THE CHICAGO AREA.

H. P. Ramey.
ASCE Proc, J Hydraul Div, Vol 85, No HY 4, Paper 1995, pp 11-37, 1959.

Descriptors: *Storm runoff, Outlets, Storms, *Storm drainage.
Identifiers: *Urban drainage, *Chicago, Ill.

From a review of past and recent conditions of flooding in the Chicago area, it is concluded that the present outlet channels are inadequate to handle the run-off during heavy storms. Possible methods of improving the situation are indicated and discussed.

481

### FLOODING FREQUENCIES FOR URBAN DRAINAGE DESIGN.

E. S. Rowe, and E. D. Storr.
Australian Road Res, Vol 2, No 10, pp 24-30, Dec 1966.
(through Eng Index, p 2321, 1967).

Descriptors: *Rainfall intensity, *Storm runoff, *Design, Pipes, *Drainage systems, *Highways.
Identifiers: *Urban drainage, Sydney, Australia.

Effects on expected rainfall intensity, run-off, pipe sizes and cost of using different flooding frequencies for road drainage design are illustrated for situation in Sydney, Australia.

482

### PROGRESS REPORT (STUDY OF RATIONAL METHOD).

John C. Schaake, Jr.
Progress Report of the Storm Drainage Research Project, Johns Hopkins Univ - Report No XI.

Descriptors: *Rainfall intensity, *Storm runoff, Storm drainage.
Identifiers: *Urban drainage, *Calculations.

The observations of 19 gaged urban drainage areas was used to verify or study the Rational Method. The concentration time used was the center of mass of the rainfall hyetograph and the runoff hydrograph. The C-factor was determined by plotting frequency distributions of observed rainfall intensities and peak runoff rates on logarithmic probability paper. Equations for concentration time and "C" factor are given provided the drainage area has certain characteristics.

483

### SUBURB MEETS URBANIZATION HEAD-ON.

Ayers, Lewis, Norris, and May, Ann Arbor, Mich.
R. J. Smit, R. [illegible]. Robinson, and T. W. Swift.
Water Wastes Eng, Vol 4, No 11, pp 47-9, Nov 1967.

Descriptors: *Design, *Sewers, *Construction costs, Grants.
Identifiers: *Urban drainage, Intercepter sewers.

The doubling of student enrollment since World War II at the University of Michigan has exerted considerable pressure on living facilities in the three surrounding areas, East Lansing, Lansing and Meridian Township. The existing sewage treatment plant was overloaded. The three areas negotiated to divide the costs of a new sewage treatment plant, new on-campus interceptors and new sewer main construction. Design of the main sewer system is discussed. Obstacles in planning and financing of the undertaking are described. Lateral sewers in 12 districts were financed by bonds totalling $1.84 million. In addition some financing was available through federal grants. The total construction costs were about $3.8 million. It is hoped that the lessons learned by this township government in facing the challenge of growth will be useful to other suburban communities with similar problems.

484
STUDIES OF SEVERE RAINSTORMS IN ILLINOIS.

G. E. Stout, and F. A. Huff.
ASCE Proc, J Hydraul Div, Vol 88, No HY4, p 129, July 1962.

Descriptors: *Rain gages, Watersheds, *Storms.
Identifiers: Urban drainage.

Study included a network of 10 recording rain gages on a 10 sq mi urban area and investigated distribution characteristics of heavy rainstorms over urban watersheds for 10 year period. It was found (1) twice as many excessive quantities occur within a 10 $mi^2$ area compared with a specific point within area; (2) the percent of the 10 $mi^2$ area experiencing excessive rainfall increases with increasing storm duration; (3) majority of the excessive quantities of rainfall lasting from 30 to 24 hr occur in the same storms; (4) although a single rain gage records only a portion of the excessive rate occurrances in 10 $mi^2$, a point rainfall record is satisfactory index of frequency distribution of areal mean rainfall; (5) urban influences, if present, are not of practical significance in the distribution of excessive quantities.

485

THE HYDROLOGY OF URBAN RUNOFF.

A. L. Tholin, and Clint J. Keifer.
ASCE Proc, J Sanit Eng Div, Vol 85, No SA2, p 47, 1959.

Descriptors: *Rainfall-runoff relationships, *Design storm, *Land use, Sewers, *Hydrographs, *Design, Runoff.
Identifiers: *Urban hydrology.

Presented in this paper is a detailed study of rainfall-runoff relationships in urban areas based upon a "Design Storm" for three hours duration. Several types of uniform land use with various values of ground slope and depression pondage have been studied. Based on the sewer hydrographs, a series of "easy-to-use" design charts are presented.

486

A TIME INTERVAL DISTRIBUTION FOR EXCESSIVE RAINFALL.

H. C. S. Thom.
ASCE Proc, J Hydraul Div, Vol 85, No HY7, p 83, 1959.

Descriptors: Rainfall intensity, *Sewers, *Design.

The methods usually used for frequency analysis of excessive precipitation average the recurrence intervals and thus obscure much useful information for the design of sewerage systems. Additional information can be obtained however by relating probability to recurrence interval instead of rainfall depth, thus giving the distribution of recurrence interval for a predetermined amount of rainfall.

487

[PROBLEMS OF WATER DISCHARGE IN URBAN AREAS.] Problemen van waterafvoer in stedelijke gebieden.

F. B. Veldkamp.
Commissie voor Hydrologisch Onderzoek T N O-Verslagen en Mededelingen, No 9-Verslag van de Technische Bljeenkomst, No 18, pp 73-94, 1963. (through Eng Index, p 1870, 1964).

Descriptors: *Discharge (water), *Rainfall-runoff relationships, *Storm runoff.
Identifiers: *Surface permeability, *Urban hydrology, Urban drainage.

Problems of water discharge in urban areas are discussed. Discharge is calculated from rainfall and runoff from area of roofs, street and sidewalk surfacings, and backyards connected to sewer system. Runoff is assumed to be 100 percent. Storage basins are calculated from storms with frequency lower than once every year.

488
RUNOFF ESTIMATION FOR VERY SMALL DRAINAGE AREAS.

Warren Viessman.
Water Resources Res, Vol 4, No 1, pp 87-94, Feb 1968.

Descriptors: *Storm runoff, *Hydrographs, *Runoff forecasting, Rainfall-runoff relationships.
Identifiers: *Urban hydrology.

Analyses of hydrologic data from high-intensity short-duration storms on very small drainage areas having varying physical characteristics indicated that a 1-minute unit hydrograph could be used as the basis for generating runoff from an effective rainstorm input. The single parameter of the unit hydrograph (time constant K) was shown to be related to the physical characteristics of the drainage area. No evidence of the correlation between K and the storm pattern was discovered. Procedures are given for estimating net storm inputs.

489
THE HYDROLOGY OF SMALL IMPERVIOUS AREAS.

Warren Viessman.
Water Resources Res, Vol 2, pp 405-412, 1966.
(through Water Pollut Abstr, Vol 40, No 11, p 494, Nov 1967).

Descriptors: *Storm runoff, *Hydrographs, Rainfall-runoff relationships.
Identifiers: *Urban drainage, *Urban hydrology, Surface permeability.

A method for computing storm-water run-off from small, impervious, urban areas is described in which consecutive 1-minute unit hydrographs are determined for a storm and summed to provide a total outflow of hydrograph. Calculations are based on the assumption that such areas behave as linear reservoirs and take account of the drainage-area lag time and losses due to depression storage. Good agreement was obtained between actual and computed hydrographs, and peak discharges for 30 storms were predicted with an average absolute error of 9 percent.

490

# PROGRESS REPORT ON THE STORM DRAINAGE RESEARCH PROJECT, JULY 1, 1958 TO JUNE 30, 1959.

Warren Viessman.
Johns Hopkins Univ, Dep Sanit Eng Water Resources, Baltimore, 1959.

Descriptors: *Storm drainage, *Runoff forecasting, Storm runoff, Hydraulics, *Intakes, *Design, *Rain gages, *Weirs, *Flow measurement, *Instrumentation, *Rainfall-runoff relationships, *Rainfall intensity.
Identifiers: *Urban hydrology, *Urban drainage.

In 1949, a research project was initiated in Baltimore, Md., to solve problems connected with urban storm drainage, including the development of a reliable method for predicting storm water run-off. In the first 7 years, the hydraulic characteristics of storm water inlets were investigated, and on the basis of the results, the design of such inlets was modified, a very efficient square grate was designed, and a method was provided for matching the inlet capacity with the drain capacity. New instruments have been developed for measuring and recording rainfall and storm run-off, including a special weir for measuring flows into storm water inlets, and a pressure-type depth-recording system. At present, studies are being carried out on the hydrological relations between rainfall and urban run-off. On the basis of measurements of rainfall and run-off over a period of 4 years, it was concluded that the Rational Method used in designing urban storm drainage systems gives unreliable estimates of the peak rate of run-off, and a new method of design, known as the Inlet method, was developed. This method is based on the maximum 5-minute rainfall intensity at each inlet, and a study has therefore been made of the relation between maximum and short-interval rainfall intensity and the duration of the intense part of a storm. Studies are also in progress to determine the range of applicability and statistical validity of the new method, the effect of antecedent rainfall on the peak discharge for a drainage area, and the timing and attenuation of storm water flows in closed drainage systems.

491

## HYDROLOGIC EFFECTS OF URBAN GROWTH -SOME CHARACTERISTICS OF URBAN RUN-OFF.

A. O. Waananen.
U S Geol Surv Prof Pap 424-C, C.353-C356, 1961.

Descriptors: Land use, Runoff, *Storm runoff.
Identifiers: *Urban drainage, *Urban hydrology.

The author discusses the effects of urban development on flow in streams. The changes in run-off characteristics following urban growth are illustrated graphically. Peak run-off from developed areas may be 3-4 times that from upstream or adjacent natural areas. In urban areas, a substantial part of the run-off occurs during a short period following a storm and the rapid discharge into receiving channels and streams reduces the opportunity for evaporation and transpiration as well as infiltration and percolation.

492

## SURFACE WATER DRAINAGE--REVIEW OF PAST RESEARCH.

L. H. Watkins.
Inst Munic Eng J, Vol 78, No 4, pp 301-20, Oct 1951.

Descriptors: *Drainage, *Design, *Surface runoff, Sewers, *Rainfall intensity.
Identifiers: Great Britain, United States, Calculations, *Surface permeability, *Sewer infiltration.

Critical review of principal investigations carried out on drainage in England and U.S.; methods for designing surface water sewers; methods of obtaining design intensities of rainfall by means of local records kept over many years; runoff reaching sewer, expressed by impermeability factor of drainage area; American development of curves showing amount of infiltration. Bibliography.

493

# THE DESIGN OF URBAN SEWER SYSTEMS. RESEARCH INTO THE RELATION BETWEEN RATE OF RAINFALL AND THE RATE OF FLOW IN SEWERS.

L. H. Watkins.

D S I R Road Res Tech Pap No 55, H M Stationery Office, London, 1962.

Descriptors: *Design, Sewers, *Rainfall-runoff relationships, Runoff, *Instrumentation, Storms, *Hydrographs, *Computer programs.
Identifiers: *Urban drainage, *Surface permeability.

A report is given of research carried out by the Road Research Laboratory on the relation between the rate of rainfall and the rate of run-off from urban areas, principally intended to lead to a method for calculating the rate of run-off in sewerage systems that would be accurate and reliable under as wide a range of conditions as possible. Rainfall and run-off were recorded at 12 experimental catchment areas, representing a wide range of sizes, types of development, locality, and other variables; and the rates of run-off calculated from the recorded rates of rainfall by 5 different methods were compared with the recorded rates of run-off. Descriptions are included of the experimental catchment areas and of new recording instruments which were developed for use in these investigations. A total of 286 storms was analyzed and it was concluded that the Rational (Lloyd-Davies), Tangent, and Modified Tangent methods for calculating run-off were unreliable for use in the design of sewerage systems, although the Rational method could be used for relatively small areas, such as housing estates and villages, where there are no sewers larger than about 24 inches in diameter. The usual Unit Hydrograph method was also unsuitable for the design of urban sewerage systems owing to difficulties in determining the shape of the unit hydrographs. The Road Research Laboratory therefore devised a new hydrograph method which is reliable under all conditions and will be used in conjunction with an electronic digital computer. It was also concluded that in calculations for the design of sewers, subject to some qualifications in exceptional circumstances, the whole area of paved surface in an urban area should be considered impermeable, and the unpaved areas should be considered completely pervious.

494
TIME IN URBAN HYDROLOGY.

G. E. Willeke.
ASCE Proc, J Hydraul Div, Vol 92, No HY 1, paper 4615, pp 29-31,
Jan 1966.
(through Eng Index, p 1322, 1966).

Descriptors: *Rainfall-runoff relationships, Rainfall intensity,
Watersheds, *Hydrographs.
Identifiers: *Urban hydrology.

Analysis of lag time (defined as time between centroids of effective precipitation and runoff) from nine small urban watersheds shows that lag time variability is small and that lag time is not correlated with storm intensity. Effective precipitation can be routed through storage by Muskingum method to accurately reproduce observed runoff hydrograph. Effective precipitation is separated from total precipitation by phi-index. Precipitation loss on watershed is closely represented by linear relationship between total storm precipitation and total storm runoff.

495
PRELIMINARY STUDY OF EFFECT OF URBANIZATION ON FLOODS IN JACKSON, MISSISSIPPI.

K. V. Wilson.
U S Geol Survey-Prof Pap 575-D, pp D259-61, 1967.
(through Eng Index, pp 56-7, Apr 1968).

Descriptors: Land use, *Flood forecasting.
Identifiers: *Urban hydrology, *Urban drainage, Surface permeability.

Comparison of flood-frequency curves for three streams near Jackson, Miss, based on annual maximum floods for period 1953 to 1966, and for another stream for shorter period, indicates that mean annual flood for totally urbanized basin is about 4 1/2 times that of similar rural stream. It further indicates that 50-yr flood for such urbanized basin is about three times that of rural stream.

496
CITY OF OAKLAND DEVELOPS NEW RAINFALL INTENSITY-DURATION CURVES.

D. M. Winton.
Public Works, Vol 90, No 7, p 120, 1960.

Descriptors: *Rainfall intensity, Design.
Identifiers: *Storm sewers, *Calculations, Oakland, Calif.

Based on a report compiled by L. A. Fites, the author gives a brief account, with tables and graphs, of the 1958 rainfall intensity-duration curves now being used in the city of Oakland, Calif., for the design of storm sewers.

497
WATERFRONT RENEWAL IN METROPOLITAN AREAS.
Wisconsin Dep Resource Devel, Madison, Wis.
Donald F. Wood.
ASCE Proc, J Urban Planning Develop Div, Vol 93, No UP4, pp 199-213, Dec 1967.

Descriptors: *Drainage systems, Flood control, Water pollution control, Planning, Recreational facilities, Storm runoff, Land use.
Identifiers: *Urban drainage.

Many of our urban waterfronts are blighted because of age and conditions unique to their location, such as vulnerability to flooding or surface water pollution. A range of actions, from simple clean-up to full scale clearance and relocation, can be used to fight waterfront deterioration. Metropolitan and basinwide approaches are needed because frequently an individual city cannot control what happens upstream or on the other side of a river. Federal urban renewal programs help to reduce the local cost. In a metropolitan waterfront renewal program the engineer must determine the condition of all shore lines and the costs of repairing or replacing it. New uses can be found for old waterfront structures. Altering the amount of shore line; providing open space and access; reducing flood and storm damage; and renewing for navigational, waterfront industrial and recreational uses are also discussed. Providing adequate storm drainage for the renewal area is an important part of an improvement plan. This drainage system could be designed to improve drainage in a larger area than just the renewal project and the area benefitting can share costs. Aspects to be considered in planning include increased runoff due to development upstream, old dams, dredging of channels and winds. Some solutions are offered.

498
A METHOD OF URBAN DRAINAGE DESIGN FOR REGIONS OF HIGH RAINFALL INTENSITY.

I. R. Wood.
Civ Eng Trans, Inst Eng, Australia, CE1, No 1, p 38, 1959.

Descriptors: *Rainfall intensity, *Design, *Drainage systems, *Storm runoff, Design storm, *Hydrographs.
Identifiers: Urban drainage, *Surface permeability.

The author considers that the Rational Method is unsuitable for the design of suburban drainage systems in regions where the design intensity is so high that run-off occurs not only from the impervious area but also from the pervious area, such as lawns and gardens. He suggests that a better method would be to determine a design storm pattern, subtract a loss rate curve, and translate the excess rain into hydrograph form using overland flow equations. The application of the method to conditions in Canberra is described. Approximations are suggested to make it possible to use the procedure for routine design.

499
HARVARD GULCH FLOOD CONTROL PROJECT.

K. R. Wright.
ASCE Proc, J Irrig Drain Div, Vol 93, No IR1, paper 5132, pp 15-32, Mar 1967.
(through Eng Index, p 886, 1967).

Descriptors: *Flood control, *Model studies, Intakes, *Design, Construction.
Identifiers: *Urban hydrology.

Planning, design, and construction of major urban flood control project is presented. Emphasis is placed on flood hydrology investigations used as basis for sizing of culverts, open channels, and structures. Information is given on model testing of inlet structure to assure control of rate of flood waters entering outfall culvert. Techniques for designing open channels, both concrete and grass-lined, are described. Underflow pipes were used to carry normal low flows. Planning of construction schedule by design engineer is described, together with methods of construction and results of alternate bids for large diameter concrete pipe and concrete box culvert.

# Section XI

# RAINFALL - RUNOFF RELATIONSHIPS

259-A

500
PROBLEMS OF HYDROLOGICAL FORECASTS.
Institute for Hydrotechnical Studies and Research.

Studii Hidrol, Inst Studii Cerc Hidroteh, Vol 13, 1965. 208 pp, 2 tab.
(through Water Pollut Abstr, Vol 39, No 11, p 363, Nov 1966).

Descriptors: *Runoff forecasting, *Hydrographs, Discharge (water).
Identifiers: Roumania.

This publication contains the full text of 5 papers on the prediction of run-off and stream flow with special reference to conditions in Roumania. Aspects considered include the short-range forecasting of run-off by the trend method; forecasting of hydrographs of floods caused by precipitation, using the isochrones method; forecasting of mean discharges in the Danube over periods of 10 and 5 years, based on the water resources in the drainage area; short-range forecasting of discharges in the rivers Somes, Mures, Jiu, Olt and Siret, based on water resources in the drainage area; and short-range forecasting of freezing and the breaking-up of ice on Roumanian rivers.

501
RESEARCH REPORT OF THE CITY AND GUILDS COLLEGE, 1961-64. 110 pp.
Imperial College of Science and Technology (University of London).

(through Water Pollut Abstr, Vol 39, No 11, pp 361-2, Nov 1966).

Descriptors: *Rainfall-runoff relationships, Computer programs, Model studies.
Identifiers: *Calculations.

This report includes sections on engineering hydrology (pp. 53-54) and public health engineering (p. 54). Studies on surface waters have included the flood response of a river to rainfall, propagation of a flood wave along a river, mechanism of run-off from an artificial catchment receiving "rain" from a sprinkler, design of a network of hydrometric stations, and the use of modern techniques, including digital and analogue computers, to analyze hydrological data and investigate the relations between rainfall and run-off. A mathematical study was made of the flow of irrigation and rain water to horizontal tube drains, and the mathematics of diffusion were applied to the description of unsteady flow of ground water. Studies were also made on the relation between hydrology and water demand, particularly for irrigation, and on the management and planning of water resources, including the design and operation of storage reservoirs. In connection with water and sewage treatment, model and prototype studies were made on the mixing characteristics of horizontal-flow sedimentation tanks, and work on mixed-bed filtration led to the development of an efficient graded filter with layers of polystyrene, anthracite, sand and garnet, the strata being graded so that they retain their relative positions during back-washing and so that the pore space decreases in the direction of flow, with consequent deeper penetration of removable material.

502
SOLUTION TO SURFACE RUNOFF PROBLEM.

A. Y. Abdel-Razaq, W. Viessman, Jr., and J. W. Hernandez.
ASCE Proc, J Hydraul Div, Vol 93, No HY6, Paper 5606, pp 335-52, Nov 1967. 11 ref.
(through Eng Index, p 248, Feb 1968).

Descriptors: *Hydrographs, Runoff, Surface runoff.

Surface runoff hydrographs are computed by relatively simple method consisting of reducing governing partial differential equations at several nodal points along flow plane. These equations are then solved for time derivatives which are used in Taylor's series to approximate velocity and depth after increment in time. Comparison with experimental data shows that runoff hydrographs were reproduced fairly accurately. Numerical solution was shown to be stable and truncation errors negligible.

503
ON STRUCTURE OF COAXIAL GRAPHICAL RAINFALL-RUNOFF RELATIONS.

A. Becker.
Int Ass Sci Hydrol - Bull, Vol 11, No 2, pp 121-30, June 1966.
(through Eng Index, p 2277, 1967).

Descriptors: *Rainfall-runoff relationships, *Rainfall intensity.

This paper, supported by investigations into extreme conditions and events - i.e., moisture-oversaturated river basin, threshold concept, instantaneous rainfall and rainfall of extreme amount - supplies general information on structure of coaxial graphical rainfall-runoff relations and on physical laws primarily controlling shape of curves in individual quadrants of coaxial relations.

504
CONCEPTION OF A MODEL FOR DETERMINING THE LAWS OF RAIN DISCHARGE RELATIONS. (in German).

A. Becker.
Wasserwirtsch - Wassertech, Vol 18, No 1, pp 16-21, Jan 1968.

Descriptors: *Model studies, *Rainfall-runoff relationships, Flow measurement, *Surface runoff, Runoff forecasting.

Rain discharge relations, especially on the surface of rivers, play a significant role in the forecasting of floods, because they make it possible to achieve a maximum time advance in making the forecasts. A model is developed (based on unit territorial and rain relations) to deduce the rain discharge relationships from threshold values and other simple quantities. An example is given for which - on the basis of favorable conditions - an approximate determination of the surface water retention was possible by considering the surface water states at two representative measuring stations.

505
SURVEY OF RECENT DEVELOPMENTS IN RAINFALL-RUNOFF ESTIMATION.

E. C. Bell
Inst Eng, Australia J, Vol 38, No 3, pp 37-47, Mar 1966. 73 ref.
(through Eng Index, p 2648, 1966).

Descriptors: Rainfall intensity, *Computer programs, *Rainfall-runoff relationships, *Model studies.

Advances in estimating streamflow from given quantities of rainfall that were made by simulating hydrological phenomena with high-speed computers are surveyed. It is shown that some of these techniques are based on rather artificial models of physical processes and could give poor predictions for extreme or uncommon conditions. Individual processes are studied and it is suggested that most models could be improved.

506
EFFECT OF SNOW COMPACTION ON RUNOFF FROM RAIN OR SNOW.

F. A. Bertle.
U S Bur Reclamation-Eng Monographs, No 35, June 1966. 45 pp.
(through Eng Index, p 1195, 1967).

Descriptors: *Runoff, *Snowmelt, Design storm, *Rain.

Computational procedure for determining water available for runoff and its time of occurrence resulting from rain-on-fresh-snow condition is presented. Procedure includes estimate of shrinkage of snow pack caused by metamorphosis of crystalline structure with addition of rainfall. Examples are given showing use of procedure with assumed design storm conditions. Procedure is used to reproduce observed flood which verifies accuracy of method and assumptions and is intended for use in inflow design flood study in which design rain occurs on fresh snowpack.

507
A MATHEMATICAL MODEL FOR RELATING RUN-OFF TO RAINFALL WITH DAILY DATA.

W. C. Boughton.
Civ Eng Trans, Inst Eng, Australia, Vol CE8, No 1, pp 83-97, 1966.
(through Water Pollut Abstr, Vol 39, No 12, p 398, Dec 1966).

Descriptors: *Model studies, *Rainfall-runoff relationships, Rain gages.

The author describes the development and use of a mathematical model to simulate the changes of moisture in a catchment using daily rainfalls and evaporation records as data; the principal physical processes reproduced in the model, namely, evapotranspiration losses, soil moisture storage, and infiltration losses, are discussed. The model has been used with records from 6 gauged catchments in New South Wales, and showed reasonable correlation between recorded and estimated run-offs; the results also suggested a possible explanation of the difference in infiltration rates between plot experiments and natural catchments.

508
A TECHNIQUE FOR ANALYSIS OF RUN-OFF HYDROGRAPHS.

D. L. Brakensiek.
J Hydrol, Vol 5, pp 21-32, 1967.
(through Water Pollut Abstr, Vol 41, No 4, p 166, Apr 1968).

Descriptors: *Hydrographs, *Runoff, *Computer programs.

A single function, based on a transformation of the Pearson type III equation, was used to fit simple hydrographs, provision being made for the independent evaluation of discharges for the rising and falling limbs. Fitting principles, including those for computer use, are discussed and detailed, and a Fortran II source program written for an IBM 1620 computer is listed. Using an on-line plotter, calculated hydrograph points were compared visually with observed curves.

509
UNIT GRAPHS FOR NONUNIFORM RAINFALL DISTRIBUTION.

J. A. Buil.
ASCE Proc, J. Hydraul Div, Vol 94, No HY1, paper 5762, pp 235-57, Jan 1968. 9 ref.
(through Eng Index, p 158, Apr 1968).

Descriptors: Drainage, *Runoff, *Hydrographs.

Correlation between Snyder's basin constants Ct and 640 Cp and basin physical characteristics of drainage area, total length, average slope length to center of area, and elongation is established using synthetic data. Actual data are used to compensate for discrepancies introduced through initial use of synthetic data. Effects of nonuniform rainfall distribution on basin runoff hydrograph is represented by unit graph, selected from three computed for each basin. Computation formulas are presented to define each of three basin unit graphs. Dimensionless unit graph is introduced for more accurate definition of rising and falling links of each unit graph.

510
RELATION OF ANNUAL RUNOFF TO METEOROLOGICAL FACTORS.

M. W. Busby
U S Geol Survey-Prof Pap 501-C, p C188-9, 1964.
(through Eng Index, p 2162, 1965).

Descriptors: Runoff, *Runoff forecasting, Rainfall-runoff relationships.

Average annual runoff at 62 selected stations throughout conterminous United States was related to nine meteorological factors as recorded at U S Weather Bureau first-order weather station near each point of runoff study. Seven of these factors were significant at 80 percent level or higher. On basis of these seven factors, standard error of estimate of average annual runoff is about 30 percent.

511
RAINFALL-RUN-OFF RELATIONS IN THE UPPER GOULBURN RIVER CATCHMENT, N.S.W.

T. G. Chapman.
Civ Eng Trans, Inst Eng, Australia, Vol CE5, pp 25-35, Aug. 1963.
(through Water Pollut Abstr, Vol 37, No 2, p 55, Feb 1964).

Descriptors: *Rainfall-runoff relationships, *Rain gages, *Storm runoff, *Groundwater recharge, *Rainfall intensity.
Identifiers: *Calculations.

The author describes the methods developed to determine the relation between rainfall and run-off in the Upper Goulburn river catchment in New South Wales, a large catchment for which records of stream flow and daily rainfall were available but there were no data on rainfall intensity. The network of official rain gages were supplemented by records from privately-operated instruments; these had a slightly lower standard of consistency but were of adequate quality for use in the analysis. Linear regression techniques were used to estimate mean winter and summer rainfalls for each station for a common 50-year period; isohyetal maps for mean seasonal rainfalls were then developed by correlating the estimated rainfall for each station with its altitude and a third variable dependent on topography or location. About 75 percent of the variation in rainfall was accounted for in this way, compared with 37 percent when altitude was the only variable. The stream-flow record was used to estimate, within wide limits, the mean annual recharge to ground water and to calculate the direct run-off from 242 storms in 47 years. The relation between rainfall and run-off was developed by multiple regression analysis, which was first used to compare the efficiency of different predictors of rainfall intensity and catchment dryness.

512
LABORATORY STUDY OF WATERSHED HYDROLOGY.

V. T. Chow.
Paper, Int Hydrol Symp, Fort Collings, Colo, Sept 1967, U of Illinois, Urbana. 14 p, 3 fig, 7 ref.
(through Water Resources Abstr, Vol 1, No 2, Feb 1968).

Descriptors: *Rainfall-runoff relationships, *Watersheds, *Storm runoff, *Model studies, *Computer programs, *Roughness (hydraulic), Discharge (water).

A conventional approach to study the rainfall-runoff relationship of a watershed uses historical hydrologic data to fit a black-box model for simulation of watershed hydrologic behavior. Although many measurements of rainfall input and runoff output from watersheds are available, no general theory explaining the course of flow mechanics from input to output exists. The proposed laboratory approach investigates basic laws and principles controlling mechanics of runoff from a watershed. It employs a watershed experimentation system (WES) as a tool for the research. The WES is an instrumentation system of integrated hydraulic, electronic, and structural design that can produce an artificial rainfall of variable time and space distribution to move over a laboratory area of 40 by 40 ft or less; thus, it is capable of simulating a storm moving in any direction over a testing drainage basin constructed within the area. The experiment is controlled electronically by a digital computer, and output runoff is measured by sonar detectors which transmit information to the computer for immediate recording and analysis. Various problems being studied include the time factor in runoff process, conceptual watershed roughness, and effect of storm movement on peak discharges. The WES also may be used to study subsurface runoff by employing testing basins made of porous materials.

513
SEQUENTIAL GENERATION OF RAINFALL AND RUNOFF DATA.

V. T. Chow, and S. Ramaseshan.
ASCE Proc, J Hydraul Div, Vol 91, No HY 4, Pt 1, paper 4416, pp 205-23, July 1965.
(through Eng Index, p 2044-5, 1965).

Descriptors: *Storm runoff, *Drainage systems, *Rainfall-runoff relationships.
Identifiers: *Calculations.

Practical procedure is demonstrated by applying sequential generation techniques to rainfall and runoff data for stochastic, hydrological analysis of drainage basin systems. In this method, stochastic process is formulated by several major components including hourly annual storm rainfalls, abstractions, routing model, baseflow, direct runoff, and total runoff. 1000 annual storms are generated sequentially by Monte Carlo methods and then routed through simulated basin system to produce 1000 generated floods which are represented by stochastic flow-duration curves for use in water resources planning and design.

514
CONCEPTUAL MODEL OF HYDROLOGIC CYCLE.

N. H. Crawford, and R. K. Linsley.
Int Geod Geophys Union - Sect Sci Hydrol Publ, No 63, pp 573-87, 1964.
(through Eng Index, p 1062, 1965).

Descriptors: *Model studies, *Watersheds, *Hydrographs, Groundwater, *Storm runoff, Rainfall-runoff relationships, *Computer programs.

Model called Stanford Watershed Model (Mark II) utilizes hourly ordinates of hydrograph during and immediately after rain and mean daily ordinates for interim periods. Print-out includes monthly and annual flow, monthly groundwater runoff, end of month soil moisture, and flow duration curve of daily runoff. Model includes among its components surfaces, interflow, and groundwater runoff. Model has been tested on basis embracing variety of climatic, hydrologic, and geologic conditions.

515
DISCHARGE FROM HEAVY RAINFALL.

E. E. Dawson.
Inst Civ Eng Proc, Vol 25, pp 373-374, 1963.
(through Water Pollut Abstr, Vol 37, No 1, p 13, Jan 1964).

Descriptors: *Discharge (water), *Rainfall-runoff relationships.

In connection with previous work on discharge from heavy rainfall further studies have shown that no serious error was introducted by treating the flow as uniform (whereas the flow on the ideal catchment would be non-uniform) provided that the catchment was not very small.

516

## INVESTIGATIONS INTO THE UNIFORMITY OF RELATION BETWEEN GROUND WATER AND RAINFALL OVER PROLONGED PERIODS AND THE POSSIBILITY OF PREDICTING GROUND WATER LEVELS WITH SPECIAL CONSIDERATION OF DRY PERIODS.

J. Denner.
Dt Gewasserk Mitt, Vol 9, pp 73-85, 1965.
(through Water Pollut Abstr, Vol 39, No 10, pp 328-9, Oct 1966).

Descriptors: *Groundwater, *Rainfall-runoff relationships.
Identifiers: Calculations.

A report, including tabulated and graphical results, is given of extensive studies carried out in 6 German towns at varying intervals over a period of 54 years on the distribution of rainfall and run-off, effective precipitation and temperature and stream flow. The effect of these characteristics on the response of the water table and their relation to climatic changes are discussed; it was found that the water table tends to respond to rainfall in a characteristic pattern, making it possible to predict short-term changes in the ground-water level allowing for weather forecasts and dry weather periods. From these findings standard values for high, medium, low and very low rainfall are derived.

517

## LIMITING FACTORS IN RAINFALL RUN-OFF.

L. B. Escritt.
Eng, London, Vol 213, 1962.

Descriptors: *Rainfall-runoff relationships, *Storm runoff, *Storms, *Rainfall intensity, Design, Sewage treatment, *Runoff forecasting.
Identifiers: *Surface permeability.

When sewerage systems are being designed, the volume of storm water is often over-estimated because no allowance is made for change of impermeability during rainfall. In addition, in large catchment areas, heavy storms frequently cover only part of the total catchment, and when run-off is calculated by relating statistics of frequency, intensity and duration of rainfall to impermeable area by a time-of-concentration method, the flow may be considerably over-estimated. The author suggests methods for allowing for the change of impermeability during rainfall and for assessing the maximum areas likely to be covered by storms.

518
RAINFALLS OF SHORT DURATION AND HIGH INTENSITY: AN ALTERNATIVE TO BILHAM'S FORMULA.

L. B. Escritt.
Water Wastes Treat J, Vol 7, 1960.

Descriptors: *Rainfall intensity, Design, *Surface runoff, *Sewers.
Identifiers: *Storm sewers.

In connection with the design of surface water sewers, the author discusses the use of Bilham's formula for rainfalls of short duration and high intensity (see W.P.R. Summary, 1937, 10, Abstr. No. 189); and presents a modified general intensity formula derived from logarithmic plotting based on Bilham's formula.

519
WATER AND WASTE-WATER ENGINEERING. VOL I. WATER SUPPLY AND WASTE-WATER REMOVAL.

G. M. Fair, J. C. Geyer, and D. A. Okun.
New York: John Wiley & Sons, 1966. 1246 pp.
(through Water Pollut Abstr, Vol 39, No. 12, p 409, Dec 1966).

Descriptors: Design, Sewers, *Rainfall-runoff relationships, Surface runoff, Groundwater, Equipment.
Identifiers: *Storage tanks.

This book is based on a previous publication produced in 1954 and is designed to help students of civil and sanitary engineering to understand the principles of water supply and waste disposal. Chapters are included on water-supply and sewerage systems; information analysis; water requirements and volumes of sewage; relations between rainfall and runoff and the control and storage of runoff; flow and collection of ground water and surface water; transmission and distribution of water; collection of sewage; design and operation of machinery and equipment; optimization techniques; and carrying out of engineering projects. Information and conversion factors are given in an appendix, and a bibliography and subject index are included.

520
DETERMINATION OF THE MELT-WATER FLOW FROM THE WATER RESOURCES OF THE SNOW COVER. (in German).

H. J. Grasnick.
Wasserwirtsch - Wassertech, Vol 17, No 9, pp 302-306, Sept 1967.

Descriptors: *Snowmelt, *Runoff.
Identifiers: *Calculations.

With the aid of several statistical methods, an attempt was made to work out a prognosis for the melt-water run-off (as well as the total run-off at peak values) in some river areas of the German Democratic Republic showing various physical and geographical conditions. The investigation made use only of observation data published in the meteorological and hydrological annuals. Although this material, especially that about the snow cover, did not permit the desired fully complex statistical evaluation, nevertheless, it was possible to find certain regularities in the relationship between the water resource and run-off. The report contains results of a differential analysis of special snow investigations carried out in Spring 1965 and the author's suggestions on how to improve observation of the snow cover.

521
COMPUTING RUNOFF FROM SMALL WATERSHEDS.

C. L. Hamilton.
Public Works, Vol 96, No 8, pp 106-8, Aug 1965.
(through Eng Index, p 2648, 1966).

Descriptors: *Storm runoff, *Rainfall intensity, Watersheds.
Identifiers: *Calculations.

Use of summation "W" method for estimating runoff from small watersheds, with "W" standing for relative values of certain physical watershed characteristics that are summed up to obtain preliminary estimate of peak discharge,is discussed. Rainfall factor was developed to make adjustment in rainfall intensity as it varies throughout United States in reference to intensity chosen as standard. Sample computation is presented to illustrate application of method. Data on runoff-producing characteristics of watershed with corresponding weights.

522
THREE-DIMENSIONAL TYPE REPRESENTATION OF HYDROLOGICAL DATA.

A. A. Hirsch.
Amer Water Works Ass J, Vol 56, No 7, p 937, July 1964.
(through Eng Index, p 900, 1964).

Descriptors: *Rainfall-runoff relationships, *Data collections.

Three-dimensional method of presenting time-related values for data related to rainfall, streamflows, water levels, etc, so that 1-yr graphs can be compared over periods of many years is described. Method whereby yearly curves are cut-out, laminated in clear plastic, and mounted in plots on baseboard, for furnishing easily comprehensible volume of data in compressed form.

523
ANALYSES AND APPLICATION OF SIMPLE HYDROGRAPHS.

H. N. Holtan, and D. E. Overton.
J Hydrol, Vol 1, No 3, pp 250-64, 1963.
(through Eng Index, p 899, 1964).

Descriptors: *Hydrographs, *Watersheds, *Rainfall intensity, Storms.

Method of hydrograph analyses to derive parameters for computing hydrographs tailored to specific watersheds and specific rainstorms is presented. Simple hydrographs are analyzed to develop techniques for rapid derivation of watershed storage coefficient, and subsequently, for defining and positioning hydrograph in terms of storage coefficient and rainfall intensity period. Simple hydrographs are developed by these techniques for storm increments or for homogeneous increments of heterogeneous watersheds, and summated to derive complex, multiple-peak, or sustained-flow hydrographs.

524
### RAINSTORMS MADE TO ORDER.

L. Arthur Hoyt.
Public Works, Vol 99, No 3, pp 95-98, March 1968. 4 p, 1 fig, 2 photo.
(through Water Resources Abstr, Vol 1, No 6, p 17, June 1968).

Descriptors: *Computer programs, *Storms, *Rainfall intensity, Watersheds, *Storm runoff.

A computer controlled rainfall simulator has been developed by Ven Te Chow of the University of Illinois to produce artificial rainstorms. The simulator can develop storms of any intensity pattern, repeat them at any interval desired over all types of terrain, and measure runoff from the terrain with given conditions of absorption and other parameters, to an accuracy never before obtainable. The rainfall can be released over any part, or all, of a 40- by 40-ft artificial terrain. Types of storms are programmed and stored on computer tape so they can be started, stopped, or repeated at will. The terrain simulated can range from lush water basin areas to arid desert. Water runoff is accurrately measured. Major objective of the entire study is to investigate basic laws of flow mechanics of surface water over artifical watersheds. Descriptions of the electronic simulator and operation of major components are given.

525
### SPATIAL DISTRIBUTION OF HEAVY STORM RAINFALLS IN ILLINOIS.

F. A. Huff.
Water Resources Res, Vol 4, No 1, pp 47-54, Feb 1968.

Descriptors: *Storms, Rainfall intensity.
Indicators: *Calculations, Illinois.

An 11-year continuous record from 49 recording rain gages on 400 square miles in central Illinois has been used to derive characteristic area-depth relations in heavy rainstorms for storm periods of 30 minutes to 48 hours on areas of 50, 100, 200, and 400 square miles. First, eight general equations were statistically tested to determine the most appropriate fitting method for the area-depth curve. Overall, an equation relating rainfall depth to the square root of the area received the highest score. However, the equation that fit best was found to vary with areal size, mean rainfall, and storm duration, which, in turn, reflected general trends in relative variability and skewness of the rainfall spatial distribution. Because of the high degree of variability in the area-depth relation between storms, the analytical results have been presented as probability distributions for given sets of conditions with respect to area, storm duration, and rainfall volume. Thus, the user is provided with both average curves and curves applicable to more extreme patterns of storm rainfall.

526
TIME DISTRIBUTION OF RAINFALL IN HEAVY STORMS.

F. A. Huff.
Water Resources Res, Vol 3, No 4, pp 1007-1019, 1967.

Descriptors: *Storms, Rainfall intensity.
Identifiers: *Calculations, Illinois.

Time distribution relations have been developed for heavy storms on areas ranging up to 400 square miles and presented in probability terms to provide quantitative information on interstorm variability and to provide average and extreme relations for various applications of the findings. It was found that the relations could be represented best by relating percent of storm rainfall to percent of total storm time and grouping the data according to the quartile in which rainfall was heaviest. The individual effects of mean rainfall, storm duration, and other storm factors were small and erratic in behavior when the foregoing analytical technique was used. Basin area had a small but consistent effect upon the time distribution. The derived relations are applicable to the Midwest and other areas of similar climate and topography. They can be used in conjunction with published information on spatial distributions and other storm parameters to construct storm models for hydrologic applications.

527
DISSIPATIVE RIVER FLOW MODEL.

D. R. Jackson.
J Hydrol, Vol 6, No 1, pp 33-44, Jan 1968.
(through Eng Index, p 221, July 1968).

Descriptors: *Model studies, Rivers, Runoff.

Derivation and solution of second order differential equation of river system is presented. Model assumes routing rainfall excess through series of resistive and dissipative elements. Some suggestions for fitting model to actual data are presented. Comparison is made with other models.

528
[CALCULATION OF DISCHARGE OF RAIN DITCHES AND RAINFALL COLLECTING SYSTEMS]. Calcul des débits des fossés et ouvrages de collecte d'eau pluviales.

G. Jeuffroy, and J. Prunieras.
Constr, Vol 19, No 1, pp 21-9, Jan 1964.
(through Eng Index, p 1743, 1964).

Descriptors: *Discharge (water), *Storm drains, Rivers, Runoff forecasting.
Identifiers: *Calculations.

Method for calculating maximal flow of ditch or surface channel bordering elongated area, taking into account local meteorological factors and discharge rate of drainage system is presented. Variable discharge rate is stated by equation with partial derivatives where integration provides simple solution for flow at arbitrary time and point. Theory is applicable to flood levels on rivers.

529
RAINFALL AS AFFECTING FLOW IN SEWERAGE SYSTEMS.

C. C. Judson.
Surv, Vol 84, Nos 2168, 2169, 2170, pp 119-20, 141-3, 163-5,
Aug 11, 18, and 25, 1933.

Descriptors: *Rainfall intensity, *Runoff, *Sewers, Flow measurement, Storms.

Discussion of principal rainfall factors; area of watershed, intensity of rainfall; time of concentration; area-time diagrams; methods of calculating run-off; author's method; possible economics.

530
[RETARDATION OF DISCHARGE IN PUBLIC WATERS WITHIN THE AREA OF A COMMUNITY]. Abflussverzogerungen bei offentlichen Gewassern innerhalb eines Gemeindebezirks. (in German).

W. Kadner.
Gas Wasserfach, Vol 109, No 6, pp 158-159, 1968.

Public waters often serve as the unloading place for rainwater overflows of mixed sewer systems or rainwater mains of separate systems. In sizing such streams, it is difficult to follow the usual corresponding methods for town drainage and Kehr's rainwater run-off diagram does not permit the determination of maximum run-off any more. It is claimed that the method described has the advantage of permitting the determination of run-off at any point in the stream and thus, also, of the respective design flow. Moreover, it makes it possible to add new drainage areas and to determine the volume of the permissible maximum amount and to make corrections for the developed progress line without too much effort.

531
CONTRIBUTION TO THE DETERMINATION OF THE DIMENSIONS OF RAIN STORAGE TANKS.

W. Kadner.
Gesundh Ing, Vol 88, pp 124-127, 1967.
(through Water Pollut Abstr, Vol 40, No 8, p 352, Aug 1967).

Descriptors: Rainfall intensity, *Storm runoff.
Identifiers: *Combined sewers, *Storage tanks, *Capacity, *Calculations.

The author compares two methods, the Müller-Neuhaus and the Randolf, for the determination of suitable dimensions for storm-water tanks in combined sewerage systems. He stresses the importance of determining a progression from observations of rainfall in the place concerned and of referring to this in the calculations: those made for the town of Karlsruhe, Germany, are given as an example, with tables and graphs. No significant difference was found between the results obtained by the two methods, but the Randolf method is more suitable when a series of tanks is to be used. A bibliography is appended.

532
HYDROLOGICAL AND EFFICIENCY INVESTIGATION METHOD IN CONNECTION WITH ESTABLISHMENT OF DEVELOPMENT RATE OF SURFACE DRAINAGE.

G. Kienitz.
Int Commission on Irrigation & Drainage-5th Cong, Tokyo-Trans,
Vol 3, pp 15.495-504, 1963.
(through Eng Index, p 460, 1964).

Descriptors: *Drainage systems, Rainfall-runoff relationships, Discharge (water).
Identifiers: *Capacity.

Investigations were carried out to establish what channel flood-waves would develop in catchment area as result of precipitation, depending on discharge capacity of drainage system.

533

MEASURING RAINFALL AND RUN-OFF AT STORM-WATER INLETS.

J. W. Knapp, J. C. Schaake, and W. Viessman.
ASCE Proc, J Hydraul Div, Vol 89, No HY5, p 99, 1963.

Descriptors: *Rainfall-runoff relationships, *Rain gages, Intakes, Instrumentation, *Automatic control, Storms, *Runoff, *Storm runoff.
Identifiers: *Urban drainage.

An illustrated description is given of an instrument system which has been developed to measure rainfall and run-off in small urban drainage areas draining to storm-water inlets. The system includes a rain gauge on each area, a measuring device inside the inlets, a recorder, and controls providing automatic operation during storms. The installation can be completed with few alterations to existing drainage facilities.

534

LINEAR ANALYSIS OF RAINFALL-RUNOFF RELATIONSHIP.

V. C. Kulandaiswamy.
Instn Engr (India), J, Vol 46, No 11, pt Ci 6, pp 594-603, July 1966.
(through Eng Index, p 2384, 1967).

Descriptors: *Rainfall-runoff relationships, *Hydrographs.
Identifiers: *Calculations.

Study of relationship between rainfall excess and surface runoff by treating rainfall excess as 'inflow to' and surface runoff as 'outflow from' basin, and assuming relationship to be linear, is presented. Using Laplace transform method, expression is derived for instantaneous unit hydrograph. Various assumptions underlying existing instantaneous unit hydrograph theories and approximations made in their development are explained.

535

A BASIC STUDY OF THE RAINFALL EXCESS-SURFACE RUN-OFF RELATIONSHIP IN A BASIN SYSTEM.

V. C. Kulandaiswamy.
Thesis, Univ. of Illinois, 1964.
(through Water Pollut Abstr, Vol 38, No 10, pp 334-5, Oct 1965).

Descriptors: *Rainfall-runoff relationships, *Hydrographs, Drainage, Storms, *Surface runoff.
Identifiers: *Calculations.

After viewing various instantaneous unit hydrograph theories, the author develops a general theory for the relation between rainfall and run-off in a drainage basin. An equation is first derived for storage in the basin, and this equation is then combined with the equation of continuity to give the differential equation for the system. The theory is valid for both linear and non-linear cases. Storms over 6 natural basins were analyzed to verify the theory; the storage and surface run-off computed agreed well with observed values.

536

AN INVESTIGATION INTO INFILTRATION AND INTERCEPTION RATES DURING STORM RAINFALLS AND THEIR APPLICATION TO FLOOD PREDICTION.

Allan O. Lambert.
Inst Water Eng J, Vol 21, No 6, pp 525-35, Aug 1967. 4 tab, 8 fig.
(through Public Health Eng Abstr, Vol 47, No 12, Dec 1967).

Descriptors: *Rainfall-runoff relationships, *Hydrographs, *Runoff forecasting, Flood forecasting.

An investigation was made into the relationship between combined infiltration and interception rates during periods of heavy rainfall and factors representing various soil-moisture conditions. The hydrometric data were obtained from a catchment area of 18.5 sq miles in South Lancashire. A flood analysis method capable of predicting direct run-off in hourly intervals was developed. This method, combined with the use of unit hydrographs, provided accurate predictions of both the magnitude and temporal distribution of the river hydrographs.

537
STORAGE ROUTING METHODS OF FLOOD ESTIMATION.

E. M. Laurenson.
Civ Eng Trans, Inst Eng, Australia, Vol Ce 7, No 1, pp 39-47,
April 1965. 30 ref.
(through Eng Index, p 2045, 1965).

Descriptors: *Flood forecasting, *Model studies, *Rainfall-runoff relationships.

Estimation of floods resulting from rain storms on catchment areas by means of routing rainfall-excess through computational model representing catchment storage is discussed. Main methods and concepts necessary to understanding and use of new storage routing technique are reviewed. Several concepts are illustrated in example of application.

538
A CATCHMENT STORAGE MODEL FOR RUN-OFF ROUTING.

E. M. Laurenson.
J Hydrol, Vol 2, pp 141-163, 1964.
(through Water Pollut Abstr, Vol 39, No 4, p 124, April 1966).

Descriptors: *Surface runoff, *Rainfall-runoff relationships, *Model studies, Discharge (water), *Hydrographs, Storms.

To determine the surface run-off resulting from rainfall-excess a catchment storage model was developed by dividing the area into sections of equal storage delay time. Run-off was routed through the catchment by taking the outflow from a section plus the rainfall-excess as the inflow to the next section. The average delay time was shown to be equal to the lag for a catchment, and an empirical relation was determined between the lag and the mean discharge for a particular flood. The procedure was applied to storm data recorded at the University of New South Wales, South Creek experimental catchment, and the results were compared graphically with actual surface run-off hydrographs. Satisfactory agreement was obtained except in cases where the hydrograph rise was small.

539
THE RELATION BETWEEN RAINFALL AND RUNOFF--REVIEW PAPER.
Stanford Univ, Calif.
Ray K. Linsley.
J Hydrol, Vol 5, No 4, pp 297-311, Oct 1967. 15 p, 49 ref.
(through Water Resources Abstr, Vol 1, No 3, p 21, Mar 1968).

Descriptors: *Rainfall-runoff relationships, Surface runoff, *Hydrographs, *Computer programs.

In a period of about 300 yr, a substantial understanding of the relationship between rainfall and runoff has been developed. Perrault's original crude experiment confirming the causal relationship between rainfall and runoff was followed by a lengthy era of empiricism caused largely by inadequate data; a brief period of a quarter century in which a reasonably adequate descriptive picture of the runoff process was devised; and finally, reasonably rational correlations between precipitation and runoff. It has been demonstrated that the runoff process may be simulated on a computer with a high order of accuracy. If advantage is taken of this development to secure an adequate amount of the proper kinds of hydrologic data, a completely general simulation model may be developed which can reproduce the streamflow hydrograph on any stream, gaged or ungaged, with an accuracy at least as good as that of the data supplied to the computer.

540
ROLE OF DIGITAL COMPUTERS IN HYDROLOGIC FORECASTING AND ANALYSES.

J. P. McCallister.
Int Geod Geophys Union - Sect Sci Hydrol Publ, No 63, pp 68-76, 1964.
3 charts.
(through Eng Index, p 2082, 1965).

Descriptors: *Computer programs, *Rainfall-runoff relationships,
*Runoff forecasting, Hydrographs.
Identifiers: *Calculations.

Major goal of river forecasting computer model is to conserve as much continuity as possible between forecaster and his forecast product. Computer will provide mathematically exact forecast computation. Four hydrologic subroutines required to develop forecast program are rainfall-runoff computation, unit graph computation, stream flow routing and reservoir routing.

541

VARIATION OF RUN-OFF COEFFICIENT.

K. J. Mawson.
New Zeal Eng, Vol 14, 38, 1959.

Descriptors: *Drainage systems, *Storm runoff, *Runoff forecasting, Storms, *Rainfall intensity, Design.
Identifiers: *Urban drainage, *Wellington, N.Z.

At Wellington, N.Z., for about 30 years, storm-water drainage systems have been designed satisfactorily on the basis of the runoff-estimated by the rational method, which assumes that the highest peak flows from small catchments are produced by storms of the short-duration, high-intensity type, and generally makes no provision for prolonged falls of relatively low intensity. Data on the rainfall and floods in the residential suburb of Karori and in the bush-covered Wainui water-supply catchment area are presented and discussed with particular reference to the behavior of the run-off coefficient. It is concluded that the short-period high-intensity type of storm does not produce peak floods as high as those attained in longer storms of more moderate intensity, and that the rational method is valid for designing drainage systems for the prolonged type of storm. The run-off coefficient can be calculated with reasonable accuracy by the method in the "Provisional Standard" of the Soil Conservation and Rivers Control Council, N.Z.

542

RAINFALL AND EVAPORATION: DISTRIBUTION IN SPACE AND TIME.

P. J. Meade.
Inst Water Eng J, Vol 21, No 3, pp 210-215, May 1967.

Descriptors: *Rain gages, *Data collections, *Rainfall intensity.
Identifiers: Urban drainage.

The Meteorological Office is undertaking intensive research into the problems of the measurement, collection, and analysis of data on rainfall and subsequent evaporation to use in future planning of both water resources and water disposal. Water disposal problems requiring an accurate analysis of rainfall data include: urban drainage, roof drainage, protection of dams, embankments for railways and roads, etc. However, meteorologists are aware of another set of problems which must be attacked with determination if a comprehensive service of information and advice is to be provided in this field. These problems are concerned with the forecasting of rainfall, the time of onset, the duration, and the quantity that will fall; they range over a wide area of meteorology from the physics of clouds to the large-scale movements of the general circulation of the atmosphere.

543
EFFECTS OF CLIMATOLOGIC AND BASIN CHARACTERISTICS ON ANNUAL RUN-OFF.

S. E. Mustonen.
Water Resources Res, Vol 3, pp 123-130, 1967.
(through Water Pollut Abstr, Vol 41, No 5, p 211, May 1968).

Descriptors: *Runoff forecasting, Surface runoff.
Identifiers: *Calculations, Surface permeability, Finland.

Regression analysis was used to select climatological and basin characteristics affecting the annual run-off in Finland. Seasonal precipitation and mean annual temperature were found to be much more important than basin characteristics such as soil type and vegetation; frost depth was inversely related to run-off; while percentage areas of cultivated land and peat land were not significant factors. The statistical methods used are explained and discussed.

544
THE ROLE OF PARAMETRIC HYDROLOGY.
University College, Galway, Ireland.
J. E. Nask.
Inst Water Eng J, Vol 21, No 5, pp 435-474, July 1967. 25 ref.

Descriptors: *Rainfall-runoff relationships, *Hydrographs, Storm runoff, Model studies.
Identifiers: *Calculations.

Parametric hydrology is defined and its advantages, uses and techniques are described. The rational method is briefly described. A method of graphical correlation of observed volumes of storm run-off to the amounts and duration of rainfall and conditions in the basin at the time of the storm is described. The unit hydrograph method of measuring the distribution of run-off in time is presented. Equations and parameters are developed for this method based on basin characteristics and other variables. Conceptual models and hydrologic frequency are discussed. A lengthy discussion follows the paper.

545

STUDY OF R R L HYDROGRAPH METHOD OF DESIGNING SEWER SYSTEMS.

E. G. W. Oliver.
Chartered Munic Eng, Vol 90, No 12, pp 377-82, Dec 1963.
(through Eng Index, p 1869, 1964).

Descriptors: *Hydrographs, *Design, *Sewers, Rainfall intensity, Outlets.
Identifiers: *Calculations.

Hydrograph method of design considers changing situation over drainage area and in network of sewers at equal intervals of time, usually of one minute. Calculation reflects minute-by-minute variation in contributing area, rainfall intensity and volume of water stores. Flow diagram, or hydrograph, is evaluated and rate of flow at outfall is shown after each minute. Comparison is made with conventional rational method.

546

METHODS OF DETERMINING SURFACE DISTRIBUTION OF EXCESSIVE RAINFALLS.

J. Petrlik.
Int Geod Geophys Union - Sect Sci Hydrol Publ, No 65, pp 303-8, 1964.
(through Eng Index, p 2044, 1965).

Descriptors: Rain gages, *Rainfall intensity, Surface runoff.
Identifiers: *Calculations.

Investigation of surface distribution of heavy rainfalls in area of four largest towns in Czechoslovakia using rain gaging data of 25 yr period 1925-1949, is presented. Two basic characteristics determined for rainfalls were relation between maximum intensity of total rainfall in mm/min and its duration in place of maximum intensity in minute. Equation of horizontally diminishing intensity of heavy rainfalls was determined empirically.

547
[COMPARISON OF SOME FORMULAS FOR DETERMINING THE SNOW MELT (PRELIMINARY RESULTS)]. Betrachtungen zur Wahl von Verteilungsfunktionen für die Berechnung von Hochwasserdurchflüssen. (in German).

N. Rachner.
Wasserwirtsch - Wassertech, Vol 18, No 1, pp 10-12, Jan 1968.

Descriptors: *Snowmelt, *Runoff forecasting, *Discharge (water), Flood control.
Identifiers: *Calculations.

Run-off forecasts, especially the snow-melt water discharge prognoses, gain continuing significance in flood prevention and water management. To present a survey of possible methods and, simultaneously, to show the order of magnitude of ommissions pertaining to the simpler methods, a selection and comparison of various formulas found in the literature is made. The statements are illustrated by examples.

548
SURFACE-WATER HYDROLOGY OF CALIFORNIA COASTAL BASINS BETWEEN SAN FRANCISCO BAY AND EEL RIVER.

S. E. Rantz, and T. H. Thompson.
U S Geol Survey-Water Supply Pap 1851, 1967. 60 pp, map.
(through Eng Index, p 75, Apr 1968).

Descriptors: *Surface runoff, Planning.
Identifiers: California.

Hydrologic information for use in project planning by California Department of Water Resources and other water agencies operating in State is presented. Study of runoff regimen indicates that, for any stream, there is close relationship between flow-duration curve and frequency curves for low flows of various durations. Magnitude and frequency of high flows, for durations ranging from 1 day to 274 days, were analyzed by method that closely paralleled that used in flood-frequency study.

549
ON THE IMPORTANCE OF VOLUME DISTRIBUTION IN THE CALCULATION OF DRAINAGE SYSTEMS.

P. H. Rendsvig.
Gesundh Ing, Vol 84, pp 241-246, 1963.
(through Water Pollut Abstr, Vol 37, No 6, p 203, June 1964).

Descriptors: *Drainage systems, *Runoff forecasting.
Identifiers: *Calculations.

The author discusses a graphical method for calculating the volume of run-off to be allowed for in sewerage systems. He compares his result, based on the summation equation, with the Schoenefeldt method.

550
NOTES ON CALCULATING FLOW OF SURFACE WATER IN SEWERS.

D. W. Riley.
Inst Munic County Eng J, Vol 58, No 20, pp 1483-94, Mar 29, 1932.

Descriptors: *Surface runoff, Rainfall intensity, *Sewers.
Identifiers: *Calculations.

Methods of computing runoff corresponding to various rainfalls; intensity-duration and area-time curves.

551
LONG-RANGE FORECAST OF CRITICAL DATES OF SPRING DISCHARGE HYDROGRAPH FROM LOCAL INDICES OF ATMOSPHERIC CIRCULATION.

M. V. Rudometov.
Amer Geophys Union, Soviet Hydrol - Selec Pap, No 1, pp 31-46, 1964.
(through Eng Index, p 2081, 1965).

Descriptors: *Runoff forecasting, *Flood forecasting, *Hydrographs, Discharge (water).
Identifiers: Russia.

Methods of long-range forecasting of dates of beginning of spring high water and dates of onset of maximum discharge based on use of local indices of atmospheric circulation, taking Desna River at city of Chernigov in Ukraine as example is described.

552

MAGNITUDE AND FREQUENCY OF STORM RUNOFF IN SOUTHEASTERN LOUISIANA AND SOUTHWESTERN MISSISSIPPI.

V. B. Sauer.
U S Geol Survey-Prof Pap 501-D, pp 182-4, 1964.
(through Eng Index, p 2043, 1965).

Descriptors: *Storm runoff, Storms, Discharge (water).
Identifiers: *Calculations.

Graphical correlations indicate that mean annual, or 2.33-yr, storm runoff for any site in area is 64 sec-ft-days/sq mi, which is equivalent to uniform depth of 2.38 in. Recurrence interval of individual storm runoff will, in many instances, be significantly different from recurrence interval of peak discharge resulting from same storm.

553

SYNTHESIS OF INLET HYDROGRAPH.

J. C. Schaake, Jr.
Johns Hopkins Univ-Dep Sanit Eng & Water Resources-Tech Report 3,
June 1965. 105, p, 21 ref.

Descriptors: *Hydrographs, *Intakes, *Surface runoff, Storms, *Computer programs, *Drainage systems.
Identifiers: Calculations, Surface permeability.

Method is presented for synthesizing hydrograph of runoff from paved portions of drainage area. Method involves application of equations of gradually varied unsteady flow in open channels to describe mechanics of surface runoff. Method of synthesizing inlet hydrograph will provide means for developing records of runoff for inlet areas of sufficient length to have statistical significance. Advantage of method is that drainage area behavior can be simulated on computer so response of area to arbitrary or spatially varied rainfall can be accurately predicted.

554
EXPERIMENTAL EXAMINATION OF RATIONAL METHOD.

J. C. Schaake, Jr., J. C. Geyer, and J. W. Knapp.
ASCE Proc, J Hydraul Div, Vol 93, No HY 6, paper 5607, pp 353-70, Nov 1967.
(through Eng Index, p 248, Feb 1968).

Descriptors: *Rainfall-runoff relationships, Drainage, Runoff, *Rainfall intensity, Storm runoff, Design.
Identifiers: *Calculations, *Urban drainage, Baltimore, Md.

Rainfall and runoff data collected in Baltimore, Md. from 20 gaged urban drainage areas ranging in size up to 150 acres have been used in study of Rational Method. Results suggest that frequency of occurrence of computed design peak runoff is same as frequency of occurrence of rainfall intensity selected by designer with appropriate C. In accordance with their usual design procedures, five storm drainage designers used Rational Method to estimate 5 yr design peak runoff rates for six gaged drainage areas. These values are compared with runoff values from runoff frequency curves for these gaged areas.

555
REGRESSION MODELS FOR PREDICTING ON-SITE RUN-OFF FROM SHORT DURATION CONVECTIVE STORMS.

H. A. Schreiber, and D. R. Kincaid.
Water Resources Res, Vol 3, pp 389-395, 1967.
(through Water Pollut Abstr, Vol 41, No 6, p 260, June 1968).

Descriptors: *Storm runoff, *Rainfall intensity, *Model studies.
Identifiers: *Calculations.

Experimental plots were used to study the on-site run-off resulting from 34 summer convective thunderstorms in the Walnut Gulch experimental watershed, Ariz. It was found that run-off increased with increase in precipitation and decreased as antecedent soil moisture and crown spread of vegetation increased. Six independent variables were used in a step-wise multiple linear regression equation to determine the importance of total quantity per storm in inches; maximal 5-minute intensity in inches per hour; and duration of storm in minutes.

556

## USE OF ANALOG MODELS IN ANALYSIS OF FLOOD RUNOFF.

J. Shen.
U S Geol Survey-Prof Pap 506-A, 1965. 24 p.
(through Eng Index, p 773, 1965).

Descriptors: *Computer programs, *Flood forecasting, Runoff.

Quasilinear analog model has been developed for simulating runoff-producing characteristics of drainage system. Where storage is linear unique relationship correlating inflow and outflow peaks is derived. Technique for synthesizing flood-frequency distribution is also proposed, whereby effects of linear- or nonlinear-basin system upon its inflow probability distributions are examined.

557

## NON-LINEAR INSTANTANEOUS UNIT-HYDROGRAPH THEORY.

K. P. Singh.
ASCE Proc, J Hydraul Div, Vol 90, No HY2, Paper No 3852, pp 313-347, 1964.
(through Water Pollut Abstr, Vol 38, No 8, pp 269-270, Aug 1965).

Descriptors: *Hydrographs, *Storms, *Surface runoff.
Identifiers: *Calculations.

A theory has been developed, using a non-linear approach, to account for the apparent variations in instantaneous unit hydrographs derived from different storms over a given drainage basin. Excess rainfall with a non-uniform areal and time distribution is transformed to a direct surface run-off hydrograph at the basin outlet, with consideration of the effect of both overland and channel flows. The characteristics of such flows vary from place to place in any drainage basin, and their effects on the instantaneous unit hydrograph are considered in terms of the translation and storage factors of these flows over the basin. Analyses of storms over 6 drainage basins gave consistent results, indicating that the proposed equation can be used satisfactorily for instantaneous unit hydrographs.

558
DOUBLE-MASS ANALYSIS ON COMPUTER.

R. Singh.
ASCE Proc, J Hydraul Div, Vol 94, No HY 1, Paper 5729, pp 139-42, Jan 1968.
(through Eng Index, p 158, April 1968).

Descriptors: *Computer programs, *Precipitation.
Identifiers: *Calculations.

Hydrologists use double-mass analysis to verify consistency of precipitation or streamflow record. Precipitation of station is plotted against combined precipitation of surrounding stations. Consistency of record is verified if single straight line fitted through points is reasonable. Analysis is done on computer by fitting straight line and fourth-degre polynomial through points and comparing two sums of squares of deviations of points from fitted curves. If record is found to be inconsistent, it is adjusted by bringing deviated points along desired single straight line. Method should be of value to hydrologists having access to computers.

559
BASIC GEOGRAPHICAL AND HYDROCHEMICAL CHARACTERISTICS OF LOCAL RUNOFF OF NATURAL ZONES IN EUROPEAN TERRITORY OF U S S R.

B. G. Skakal'skiy.
Amer Geophys Union, Soviet Hydrol - Selec Pap, No 4, pp 389-434, 1966.
(through Eng Index, p 231, July 1968).

Descriptors: *Precipitation, *Surface runoff, Groundwater, *Hydrographs, Discharge (water).
Identifiers: Russia.

Consideration is given to physiographic conditions of formation from atmospheric precipitation, falling on surface of catchments, of waters of various origin that make up local runoff. Volumes of waters of various origin (surface-slope, soil-surface, topsoil-ground and groundwater) are determined by genetic separation of discharge hydrographs of small rivers. On basis of material thus obtained, quantitative description is given of genetic categories of runoff developing in specific hydrologic periods on small catchments for year of average hydrometeorological conditions, and their zonal features are established.

560

### PERCOLATION, GROUND-WATER DISCHARGE, AND STREAM FLOW IN THE NIDD VALLEY.

K. J. Smith.
Inst Water Eng J, Vol 20, pp 459-471, 1966.
(through Water Pollut Abstr, Vol 40, No 12, p 549, Dec 1967).

Descriptors: *Groundwater, *Discharge (water), Drainage, Rain, *Runoff, *Rainfall-runoff relationships.
Identifiers: Calculations, Surface permeability.

Records of drainage, taken from a percolation gage at Harlow Hill, near Harrogate, Yorks., were compared with values for stream flow, rainfall and run-off in the Nidd valley, Yorks., at 2 catchment areas, Hunsingore and Howstean. It was found that the response of percolation to rainfall was similar to that of run-off to rainfall, and this was particularly marked if mean values were taken over a long period. Statistical analysis showed that the relation between run-off and measured drainage was closest during winter and autumn, with correlation coefficients of 0.87 and 0.86 respectively; on the other hand there was a large discrepancy between infiltration at Hunsingore and measured drainage at Harlow Hill. It was concluded that the percolation gage is not a satisfactory instrument for measuring effective infiltration and that results obtained from it should be compared with run-off characteristics when the gathering grounds are relatively impermeable.

561

### WATER YIELD MODEL DERIVED FROM MONTHLY RUNOFF DATA.

W. M. Snyder.
Int Geod Geophys Union - Sect Sci Hydrol Publ, No 63, pp 18-30, 1964.
(through Eng Index, p 2648, 1966).

Descriptors: *Rainfall-runoff relationships, Runoff, Watersheds, Model studies.
Identifiers: *Calculations.

Mathematical model has been developed to analyze past records of streamflow and to predict dependable yield from watersheds under varying patterns of rainfall. Model contains three parts: first, seasonal rainfall function generates potential runoff in two phases-immediate and delayed; second, distribution function delivers delayed runoff to future streamflow; third, time-trend function compensates for changing watershed conditions. Ten test sets of data were analyzed.

562
SIMPLIFIED VERSUS OPTIMUM UNIT HYDROGRAPHS - ONE COMPARISON.
Georgia Inst Tech, Atlanta, Ga.
W. W. Snyder.
Water Resources Res, Vol 3, No 4, pp 947-948, 1967.

Descriptors: *Hydrographs, *Rainfall-runoff relationships.
Identifiers: *Urban hydrology.

A unit hydrograph is derived from a record storm previously analyzed for the optimum realizable unit hydrograph. The storm data, an urban rainfall-runoff event, and original analysis are given in Eagleson. et al Water Res. Res 2 (4):755. The simplified curve-fitting procedures produce a more rational appearing unit hydrograph in this case study.

563
NOMOGRAMS FOR THE DETERMINATION OF ANTICIPATED WATER DISCHARGE IN PLANNING RAIN RUN-OFF SYSTEMS.

A. N. Sorokin.
Vodosn Sanit Tekh, No 5, pp 12-14, 1960.

Descriptors: *Runoff forecasting, *Design.
Identifiers: Calculations, *Storm sewers.

Equations and nomograms are given for estimating the amount of run-off to be allowed for when designing storm-water sewers.

564
[RAINFALL RATES OF HEAVY RAINS IN BREMEN]. Regenspenden von Starkregen in Bremen. (In German).

W. Storch, and F. W. Boll.
Gas Wasserfach, Vol 109, No 6, pp 156-157, 1968.

Descriptors: *Rainfall intensity.
Identifiers: *Calculations, *Bremen, Germany.

Recent measurements of the rainfall intensity-duration relationship, which the municipal authorities of Bremen, Germany carried out at four measuring stations, have shown that the rainfall intensity-duration curve used for years does not correspond to present conditions. The old value was in error of 67% for 25 minutes. A new rainfall intensity-duration curve was constructed using Hoerler's method, which provided the author with data that could be used to determine rainwater rates for rainfalls of any duration and frequency. The newly constructed curve not only differs greatly from the old data, but also disagrees with the Reinhold data so far accepted as valid for the whole northwestern part of Germany.

565
RELATIONSHIP BETWEEN SURFACE AND UNDERGROUND WATERS AND USE OF WELL OBSERVATIONS IN RIVER-FLOW FORECASTING.

A. I. Subbotin.
Int Geod Geophys Union - Sect Sci Hydrol Publ, No 63, pp 513-19, 1964.
(through Eng Index, p 2082, 1965).

Descriptors: *Surface runoff, *Subsurface runoff, Discharge (water), *Rainfall-runoff relationships.
Identifiers: Russia.

Analysis of relations between groundwater level and low-water flow or minimum discharge on several Russian rivers is presented. Storm runoff-rainfall relationships are discussed.

566
ANALYTICAL CALCULATION OF STORM-WATER FLOWS IN A LARGE CHANNEL SYSTEM.

G. Supino.
Wasserwirtschaft, Vol 52, pp 122-126, 1962.
(through Water Pollut Abstr, Vol 37, No 2, p 57, Feb 1964).

Descriptors: *Storm runoff.
Identifiers: *Calculations, Italy.

The author summarizes methods developed in Italy for the calculation of storm-water run-off. These can be applied to canals, sewerage systems, and natural watercourses. The various equations and their range of application are discussed.

567
RAINFALL AND RUN-OFF IN THE DERWENT VALLEY TO YORKSHIRE BRIDGE, DERBYSHIRE.

R. W. S. Thompson, and K. J. H. Saxton.
Inst Civ Eng Proc, Vol 25, Paper No 6664, pp 147-164, 1963.
(through Water Pollut Abstr, Vol 37, No 2, p 55, Feb 1964).

Descriptors: *Rainfall-runoff relationships.

Tabulated hydrometric data over the past 60 years are given for the catchment area of the Derwent Valley Water Board on the river Derwent in north Derbyshire. The relations between rainfall and run-off in the area are discussed.

568
[HYDROLOGICAL OBSERVATIONS]. Hydrologische beschouwingen. (in German).

S. J. van Kregten.
Commissie voor Hydrologisch Onderzoek T N O-Verslagen en Mededelingen, No 9-Verslag van de Technische Bijeenkomst, No 18, pp 12-27, 1963.
20 ref.
(through Eng Index, p 900, 1964).

Descriptors: *Rainfall-runoff relationships, Discharge (water), *Hydrographs, *Storm runoff, Surface runoff, Groundwater.
Identifiers: *Calculations.

Elements of transformation of precipitation to runoff are given on basis of diagram of hydrological cycle. Methods used to determine discharge from rainfall are reviewed, with special attention to unit-hydrograph method for surface runoff. Analytical method developed in Netherlands for calculation of groundwater discharge. Behavior of flood wave in open channels is discussed.

569

STORM STUDIES IN SOUTH AFRICA-SMALL-AREA HIGH-INTENSITY RAINFALL.

W. van Wyk, and D. C. Midgley.
Civ Eng S Africa, Vol 8, No 6, pp 188-97, June 1966.
(through Eng Index, p 2279, 1967).

Descriptors: *Rainfall intensity, *Design.
Identifiers: South Africa.

Intensity-duration-frequency relationships, time distribution of intense rainfall, and areal distribution of rain within intense storms are dealt with. To enable relationships to be extended to ungaged localities, coaxial plot of intensity, duration, frequency, mean annual rainfall and rainfall region is presented. Dimensionless curve is provided as basis for synthesizing mass curve of rainfall during design storm. Third diagram is presented as basis for determining isohyetal pattern of design storm. Application to design is illustrated by example.

570

CHARACTERISTICS OF THE INLET HYDROGRAPH.

W. Viessman, Jr., and J. C. Geyer.
ASCE Proc, J Hydraul Div, Vol 88, No HY5, p 245, 1962.

Descriptors: *Rainfall-runoff relationships, *Intakes, *Rainfall intensity, Roughness (hydraulic), Runoff, *Hydrographs.
Identifiers: *Urban drainage, *Surface permeability.

The results of a study of the relationship between rainfall and runoff for impervious inlet areas are presented. An attempt has been made to include as many significant variables as possible. Prominent among the latter were antecedent rainfall storm intensity and pattern, and size, slope, and roughness of the inlet areas. Data from records on impervious areas in Baltimore, Md., Newark, Del., and Hertfordshire, England. Equations for peak rates of runoff, rise of hydrograph, and method proposed for predicting shape of simple hydrograph.

571

PROGRESS REPORT ON THE STORM DRAINAGE RESEARCH PROJECT, JULY 1ST, 1959 TO JUNE 30TH, 1960.

Warren Viessman.
Johns Hopkins Univ. Dep Sanit Eng Water Resour, Baltimore, 1960.

Descriptors: *Storm drainage, *Drainage, *Discharge (water), *Runoff forecasting, *Rainfall intensity, Weirs, Rain gages, Flow measurement, *Storm runoff, Intakes, *Design.
Identifiers: *Baltimore, Md., *Urban drainage.

Progress in the storm drainage research project at Baltimore, Md. is reported, including studies on the effect of slope on the peak discharge from small drainage areas, the effect of antecedent rainfall on the peak rate of run-off, and the relation between the maximum 5-minute rainfall intensity and the duration of the intense part of a storm; the analysis of rainfall and run-off data for the gaged inlet areas; the development of a standard weir for use in hydrological research. It is hoped that the analysis of data from the existing and proposed gaging stations will ultimately permit the development of a satisfactory procedure for predicting flows to storm-water inlets and designing the appropriate drainage system.

572

A HYDRAULIC MODEL FOR THE CATCHMENT-STREAM PROBLEM. III. COMPARISON WITH RUN-OFF OBSERVATIONS.

R. A. Wooding.
J Hydrol, Vol 4, pp 21-37, 1966.
(through Water Pollut Abstr, Vol 40, No 12, pp 548-9, Dec 1967).

Descriptors: *Model studies, *Rainfall intensity, Discharge (water), *Hydrographs, *Rainfall-runoff relationships, Drainage.

The application to field measurements of a hydraulic model of a V-shaped catchment draining into a stream situated in the apex of the V is discussed, together with the mode of determination of unknown parameters after choosing parameters for the rainfall intensity scale, catchment equilibrium time, the scale of the discharge hydrograph, and the ratio of stream-equilibrium time to catchment equilibrium time. Comparisons of discharge hydrographs calculated from the theoretical model are made with those from catchment areas at Cashmere, New Zealand, and at Alice Springs and Warragamba Dam, Australia. Improvements are suggested, including the need for a better geometrical description of the stream network in examples, and it is pointed out that a more efficient treatment of infiltration losses might be possible with a model based on stream networks.

573

HYDRAULIC MODEL FOR CATCHMENT-STREAM PROBLEM.

R. A. Wooding.
J Hydrol, Vol 3, No 3-4, pp 254-82, 1965.
(through Eng Index, p 2647, 1966).

Descriptors: *Model studies, Discharge (water) *Hydrographs, Rainfall intensity, *Rainfall-runoff relationships.

Analytical solutions for hydraulic model are obtained by method of characters, firstly, for flow over plane V-shaped catchment under constant uniformly-distributed rainfall of finite duration, and secondly, for stream outflow arising from catchment discharge predicted form of stream hydrograph is calculated numerically, assuming that rainfall is of constant intensity and of finite duration.

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